NOMINATION COVER SHEET
2016 Virginia Outstanding Faculty Awards

1. NAME

Full (Legal): William Christopher Hughes

Preferred First Name: Chris

2. INSTITUTIONAL INFORMATION

Institution: James Madison University

Rank/Position Title: Professor

Year Rank/Title Attained: 2006

Years at Institution: 18

Campus Email Address: hugheswc@jmu.edu

Campus Phone: 540-568-8069

Campus Mailing Address: MSC 4502

Campus Communications Contact:

-Name: Carol A. Hurney

-E-mail: hurneyca@jmu.edu

3. PROFESSIONAL INFORMATION

Academic Discipline: Physics

Specialization/Field: Materials Science

Type of Terminal Degree: Ph.D.

Year Awarded: 1993

Awarding Institution: UNC-Chapel Hill

4. PERSONAL INFORMATION

Please check only one box:

RESEARCH/DOCTORAL INSTITUTION NOMINEE: ☐
MASTERS/COMPREHENSIVE INSTITUTION NOMINEE: ☒
BACCALAUREATE INSTITUTION NOMINEE: ☐
TWO-YEAR INSTITUTION NOMINEE: ☐
RISING STAR NOMINEE: ☐

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Signature (President or Chief Academic Officer)

Printed Name: Dr. A. Jerry Benson, Provost and Senior Vice President
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Mission Statement

James Madison University

Mission
We are a community committed to preparing students to be educated and enlightened citizens who lead productive and meaningful lives.

Vision
To be the national model for the engaged university: engaged with ideas and the world.

Values
Academic Quality: We are dedicated to exemplary learning experiences because they are the essence of our mission.
Community: We thrive when we collaborate, respect and serve others, and appreciate our interconnectedness.
Diversity: We strive to be an inclusive community that values the richness of all individuals and perspectives.
Excellence: We seek to be innovative and to perform at the highest levels.
Integrity: We pursue ethical reasoning because it is essential to meaningful citizenship.
Student Focus: We provide experiences that challenge and support students.

SUMMARY OF ACCOMPLISHMENTS

Professor Chris Hughes joined the faculty at James Madison in the summer of 1997 at a time of great transition for the Department of Physics. The department had a long and distinguished history but was in the midst of remaking itself into something more modern and innovative. A search was conducted to find an assistant professor with a background in materials who could establish a research program and teach undergraduates while working with members of other departments across campus, and Dr. Hughes was hired. When Dr. Hughes came to James Madison, he immediately set to the task of developing a teaching portfolio for an interdisciplinary materials science program, a research laboratory that included undergraduate physics and chemistry majors, and a place in the community of faculty and students at JMU. In the 18 years since, he has achieved success in these endeavors, evidenced by the fact that he has been awarded all three of the College of Science and Mathematics' faculty awards: the Distinguished Teacher Award in 2008, the Madison Scholar Award in 2015, and the Distinguished Service Award in 2013. He is only the second faculty member in the college to receive all three awards.

Scholarship of Teaching

In his 18 years at JMU, Dr. Hughes has grown from being an effective communicator and classroom teacher to being an innovative educator who seeks to apply modern methods focused on the actions of the students as learners rather than just the skills of the instructor as a lecturer. He has implemented changes in his classes that reflect his philosophy that students learn best when they are the ones who initiate the questions, and that his role is to lead them to the point at which they feel the need to ask questions to understand what they do not know.

As a young assistant professor, Dr. Hughes utilized a conventional style of teaching, relying primarily on lectures based on scrupulously designed PowerPoint presentations and class homework meant to exercise the problem-solving skills students would need on tests and exams. He flavored his classes with personal stories and lessons learned from the research lab. However, the classes were primarily instructor driven and relied on maintaining student interest for the lecture period to keep them engaged. This is not to say he was unsuccessful at this. Student evaluations from those pre-tenure years placed him among the most highly rated faculty in the department. In the surveys from his first five years of teaching, 79% of students strongly agreed and 99% either strongly agreed or agreed with the statement "Overall, the instructor is an excellent teacher" after taking his classes.

Even with the success he had in those early years, Dr. Hughes began to look for innovations in his teaching. He attempted to improve student engagement by using computer-based systems such as introducing simulations and classroom response systems ("clickers"). But as a teacher-scholar, he came to realize that integrating his research work and his classroom teaching did not just mean taking examples from the lab and teaching them in class. It meant showing the students how to imitate the behaviors of a research scientist. A research scientist does not just consult the literature and then claim to know all there is to know about his or her discipline. The gaining of factual knowledge is just the starting point for deeper questioning, and this cannot happen until the researcher is aware of the gaps in his or her knowledge. Dr. Hughes has taken this same approach with his students in classes. He adopted the philosophy that they would never completely learn unless they gained the self-awareness of what they did not fully grasp and were then challenged to fill that gap with understanding. A very early attempt at changing the model of the classroom was through his PHYS 240: University Physics I class in the fall of 2001. This course was populated by approximately 50 first-year physics majors and second-year chemistry majors. Dr. Hughes reversed the traditional order of the class by requiring homework to be done in advance of the class. Students were expected to read the

material in the textbook, complete graded homework assignments, and come to class for the lecture on that material. The lecture was still the conventional lecture, but would now start with students knowing what they were unable to do because they had attempted the problems. In some ways, this was what we now call a “flipped classroom.” That class of students was quite successful in learning the material, but rebelled against the idea that they were being graded on material in their homework that they hadn’t yet been taught.

Based on the negative student opinions, Dr. Hughes backed away from this style of teaching. However, a problem familiar to many teachers lingered. Dr. Hughes would work to develop clear explanations, supplement them with homework, and would still have students unable to do problems directly related to the material that had been taught. In fact, it was almost as if the material had to be taught twice. The first time through, students would listen and take notes, but they would not really know what was important nor anticipate what they would eventually struggle to do. When challenged either by homework or tests, they would notice what they did not know, and they became anxious to correct these misunderstandings. Dr. Hughes recognized that he needed to come up with a way of getting students to be aware of their needs so they understood more directly. He needed to make his students want to ask questions and solve problems when they came to class. Ideally, the interactions with students in the classroom would become more like the time he spent with them during office hours when they actually asked for help. Furthermore, because the traditional lecture was primarily about transmission of content and information, it would be more efficient to introduce material to students outside of the precious three hours spent together in the classroom.

In 2012, he taught PHYS 240 again and switched to an entirely flipped mode of delivery. He personally developed over 100 video clips, each 5-10 minutes, that consisted of all the content that typically would have been delivered in lecture. In the classroom, time was spent on group problem solving or conceptual exercises drawn from physics education research at other universities. This classroom environment was very dynamic and involved Dr. Hughes roaming the room, talking to students individually and helping them get past the sticking points in their work. Occasionally, he would stop for an on-the-spot lecture when there was a particular concept that the class did not understand. As in the earlier experiment, student reaction was mixed. While all the students still rated Dr. Hughes highly and found him approachable and caring, some felt as if they were being given too much responsibility for their learning—that they weren’t being taught. However, the outcomes of the class showed that the students actually learned the material better. Many of those students have gone on to the upper levels of the physics major and now comment on the fact that preparing in advance of class and working in groups that first year taught them habits that have helped them throughout their careers.

Based on the successes of that semester, Dr. Hughes continued to develop similar materials for the PHYS 250: University Physics II course the next spring. The following year, the faculty teaching all the other sections of these two courses adopted a similar format using most of Dr. Hughes’s materials, such as the video clips and in-class exercises. Assessment data using nationally accepted instruments, such as the force concept inventory (FCI), show that the students have larger gains from these introductory courses now than they had previously. This style of teaching is now the standard approach for all physics, chemistry, and engineering majors in their introductory physics courses at JMU, that includes nearly 250 students per year. Dr. Hughes is no longer involved in this course sequence but has now moved to implementing the same changes to the even larger college physics sequence taken by life science majors.

Finally, Dr. Hughes played a pivotal role in forming new interdisciplinary programs at JMU. Along with chemist Dr. Brian Augustine, Dr. Hughes was given the task of creating a minor program in materials science at JMU from scratch. This task required not only thinking outside of the conventional physics curriculum but also researching the then current best practices throughout academia, consulting with regional industries, and finding the best way to implement this new program given the existing facilities and talent pool at JMU. The minor in materials

science that this team produced in the late 1990s still exists and provides chemistry, physics, engineering, and geology majors an opportunity to expand their undergraduate experience. Materials science minors from JMU have gone on to earn doctorates in materials science from such schools as UC-Santa Barbara, Cornell, Florida, Columbia, Northwestern, and UVa. In many cases, these students have reported that the course work in materials science at JMU gave them an initial advantage compared to students from other institutions with degrees in the basic sciences.

Scholarship of Discovery

Dr. Hughes's teaching and research work are in many ways inseparable. His original research has always been on topics chosen not only for their scientific interest but also for their accessibility to undergraduate researchers working with him as a team. This approach has created an environment where students as young as rising sophomores can feel like they have taken ownership of the research and are allowed to exercise their own creativity and inventiveness. The success of this model can be seen by the fact that Dr. Hughes has had nearly continuous external funding for his research lab since his first year at JMU, has published in leading journals, has made presentations at national meetings both by himself and with his students, and has been awarded a patent and submitted a second disclosure, both of which included undergraduate students as co-inventors. Since coming to JMU in 1997, Dr. Hughes has mentored 70 undergraduate research students and three high school teachers in summer research experiences. Of those students, 14 have gone on to earn PhDs in STEM disciplines, four have completed law degrees, four have completed medical school, four have become secondary school science teachers, and numerous others are currently continuing post-graduate education.

When Dr. Hughes first came to JMU, he had been working in one of the foremost labs in the world on short-wavelength light emitting semiconductor devices, such as UV LEDs and blue laser diodes. This research required such growth techniques as molecular beam epitaxy and metallorganic chemical vapor deposition. Such systems frequently cost well over $500,000 and require continual maintenance by technical staff, making them unsuitable for a primarily undergraduate, comprehensive institution such as JMU. Dr. Hughes looked for research projects better suited to this environment. Initially, he and his students worked on novel photoelectrochemical etching techniques for making structures in the compound semiconductor systems with which he had worked before coming to JMU. This work led to some presentations for students and communication with other labs, but he ran into the limitations of equipment available at JMU at that time. Dr. Hughes approached this challenge on two fronts. First, he worked to gain better equipment for research in materials science at JMU by submitting successful proposals to the National Science Foundation (NSF) that netted new metal deposition systems, electron microscopes, and atomic force microscopes. Second, he explored less conventional routes of accomplishing the same task by using soft lithography techniques developed in Whitesides's group at Harvard in the late 1990s and early 2000s. He shifted more to looking at the surface modification of these semiconductors with self-assembling molecules. This work produced more opportunities for student presentations and publications in conference proceedings.

The newly developed capabilities at JMU for micro fabrication and surface analysis that Dr. Hughes was a key player in developing became the fertile ground for the next important shift in his research. In materials science, there are often separate communities of those who work on such inorganic materials as silicon, gallium arsenide, and similar materials from those who work in organic materials such as polymers. Dr. Hughes bridged this gap by bringing the tools and skills he and his students had developed. Working in conjunction with his long-time associate Dr. Brian Augustine in the Department of Chemistry, a new collaboration was initiated with Dr.

James Landers of the University of Virginia. The Landers Lab was a world-class facility for the development of “lab-on-a-chip” devices, which use tiny channels in a material to perform such biochemical analyses as DNA sequencing. Drs. Hughes and Augustine combined their talents in microfabrication and surface modification and analysis to create new platforms for doing biological research. It was truly an example of integrating knowledge from across disciplines in the way that interdisciplinary research works best. No one person was expert in all things, but each had his or her own field expertise and the ability to communicate and listen in order to make the whole of the team greater than the sum of its parts.

This break into new fields of research produced some of the most productive periods of Dr. Hughes’s scholarship at JMU. New devices were made, papers were published in major chemistry journals, students wrote honors theses, and eventually a new discovery led to utilizing a newly discovered nonmaterial to modify the surface chemistry of acrylic, one of the most commonly used polymers. The true blending of teaching, as evidenced by the student research, discovery as seen in the publications and patent, and integration of knowledge as demonstrated in the collaboration across disciplines and institution types, reached full maturity. The research lab that Dr. Hughes had created with the help of Drs. Augustine and Landers fully matched the goal of JMU to be an engaged university that is collaborative and innovative by valuing undergraduate research in a scientifically productive way.

As time progressed, Dr. Hughes and his collaborators and students moved on to explore more ways of creatively make the device structures needed for the biochemical research being done at UVa. An experiment was performed to see if the new materials that they had been using could improve the adhesion of metal to acrylic surfaces. Acrylic, as most people know it in the form of Plexiglas, is a chemically inert material. However, for a particular type of device that Dr. Hughes and his team were working on at that time, it was important to be able to put nanometer thin metal layers on the surface of acrylic and have it bond well enough that it stayed in place for later processing steps. Through a series of fortuitous events, Drs. Hughes and Augustine noticed that exposing the surface to the common chemical solvent chloroform changed how well thin layers of gold adhered to the surface. This puzzling result led to two or three years of experiments and computer simulations as different models were proposed and tested to explain this novel result. Finally, a chemical model was developed, hundreds upon hundreds of samples were analyzed, and a thorough understanding was reached of what happens when gold atoms fall upon the surface of acrylic that has been treated with chloroform. The paper describing this work, with three undergraduate co-authors including one as the first author, was published in one of the higher impact surface science journals in spring 2011. In each of the first three months after its publication, this paper was among the top 10 most downloaded articles in this journal. In addition, the discovery was submitted as a patent disclosure and is currently in review by the US Patent and Trademark Office.

While Dr. Hughes and his colleagues could have spent years more looking at the details of the new surface science they had discovered, they continued to look for new questions. At this time, they teamed with Dr. Chris Deppmann of the University of Virginia to see if their expertise in microfabrication might be useful in making new platforms for neuroscience. Once again, the interdisciplinary siren called, and as of this writing, Dr. Hughes’s lab is exploring new ways of using nanotechnology and microfabrication to impact a field that few would recognize as being related to physics.

Scholarship of Integration

Dr. Hughes has not only contributed to JMU as a scientist, but also as a key voice in linking the sciences with the arts on campus. His love of music and dance (as an observer) led him to seek ways he could work with students and faculty from those programs. He believes that students in the performing arts can be enriched by understanding the laws of the natural world

that underpin their art, such as knowing how a violin makes music or how balance and angular momentum influence a piqué turn in ballet. Dr. Hughes knows that students who might not initially be open to learning physics might be more excited if it were related to something with which they were more comfortable. Thus, he shows them that their creativity is a similar intellectual pursuit to creativity that scientists must use to develop new understanding.

To meet art students on their own terms, Dr. Hughes has taken several opportunities to teach majors from these programs. He has become one of the regular cadre of physics professors who teaches the Science of Light and Sound course where music students and others learn that sound and light are waves. This class demonstrates to band members that the shape of a brass instrument influences its sound, or explains to theater majors how the lighting of a stage can change how colors on it appear.

Dr. Hughes has also worked with faculty in the dance program to develop a course that helps students understand the physics of their movements. This course involves observation of an upper-level dance class followed by a dialog about how various movements work from a mechanical point of view. Dance students do experiments, designed by Dr. Hughes, to further illuminate the relationship between the movement of the human body and the laws of physics. Dr. Hughes has learned a great deal from his interactions with these students, and has been asked to speak about physics and dance to audiences outside of JMU, including a panel discussion at the Kennedy Center for the Performing Arts and in a radio interview for the public radio show “With Good Reason.”

Scholarship of Service

One of the most important things that Dr. Hughes came to JMU looking for in 1997 was a sense of place. The best institutions of higher education all share one attribute—the people feel as though they belong there and are part of the place and the place is part of them. This is something that Dr. Hughes had experienced throughout his prior academic career from parochial schools, through a liberal arts college, on to large state flagship research universities, and finally at a comprehensive, primarily undergraduate public university. However, this sense of belonging means playing your part. You must serve the institution and try to make it a better place because you are there. Dr. Hughes has done this at JMU in many ways, including serving on numerous search committees for not only assistant professors in physics, but also for academic unit heads, associate deans, deans, and vice presidents. He served as chair of the College of Science and Mathematics faculty college council, and, for one year, acted as signature authority for the physics department while the unit head was on educational leave. However, his most prominent forms of service to the academic community and beyond have been related to supporting the integration of teaching and discovery that is widely known as undergraduate research.

One of the best known mechanisms for the funding of undergraduate research is the NSF Research Experiences for Undergraduates (REU) program. JMU has had REU programs funded in four disciplines in the last decade: chemistry, materials science, biology, and mathematics. Dr. Hughes was the principal investigator for three separate grants that funded the REU in materials science for 10 years at JMU. His work included not only writing the grant proposals, but managing the budget, recruiting the students, making arrangements for their housing and social activities, and organizing the faculty who would mentor them. He did all of this while also mentoring his own research students. One grant funded 10 students each year; more than half of these students came from other institutions including Bridgewater College, Davidson College, the University of Dayton, High Point University, the University of Mary Washington, Northern Virginia Community College, Norfolk State, Randolph College, St. Vincent College, Salem College, Sweet Briar, the University of Virginia, and Winston-Salem State University. These students joined others from JMU funded by the grant and many funded

by other sources to form a cohort of 30 to 40 students each summer working on undergraduate research in a program facilitated by Dr. Hughes.

Among those additional students were students from other countries as well. Because Dr. Hughes recognized the importance that working with international scholars had on his own development, and because this is a feature of larger research universities that is not as easily replicated at comprehensive institutions, he managed to find funding to include undergraduate researchers from around the world to join in this program. These students included three from the Republic of Ireland, one from the UK, one from Serbia, one from Korea, and one from Denmark. At least one of these students returned to Virginia to complete her PhD at the University of Virginia. In the later years of the program, the international emphasis shifted from students from developed nations to students from lesser developed countries. Two South African students came to work with the JMU materials science REU in consecutive summers. These students were both talented though perhaps not at the level where their eventual progress to graduate study could be taken for granted. They also both came from townships in South Africa where higher education was not an expected outcome for a young woman. Based on the evidence at JMU that undergraduate research can be the stimulus to push students such as these over the top and on to successful scientific careers, Dr. Hughes with Dr. Augustine recruited these students, brought them to JMU, and mentored them in their research lab. Both students graduated with honors degrees in chemistry from their South African university, moved on to graduate school, and continued in science.

Dr. Hughes's passion for undergraduate research got him involved with the Council on Undergraduate Research (CUR), a national organization that promotes the undergraduate research enterprise in many ways. Dr. Hughes was elected as a councilor in the physics and astronomy division in 2002-2003, and served in that position for 12 years. For two years, he was the chair of the physics and astronomy division, and served on the executive board of CUR. Dr. Hughes was part of several initiatives in CUR during his time as councilor. Perhaps the most notable was his initiation of a new undergraduate research conference for students from REU programs. The best known undergraduate research conference in the country is the National Conference of Undergraduate Research (NCUR), which draws thousands of students from all disciplines together each April. In addition to running NCUR, CUR runs an event called "Posters on the Hill" each spring that brings a much smaller number of students to Washington, D.C., to present their research work to senators, representatives, and staffers. As undergraduate research has become more widespread, both of these events have become more oversubscribed. The acceptance rate for applications to Posters on the Hill is now much less than 10%. As the executive board of CUR discussed this issue, Dr. Hughes recognized from his experience that many undergraduates had their research experience during the summer as part of an REU. These students would be well served by an event in the fall. Furthermore, a fall event would create a good opportunity to communicate to the staff at NSF how greatly the REU program is valued. Thus, he suggested a new conference to be held in Arlington, VA, adjacent to the NSF headquarters, for students to present posters of their REU work. He led the initial planning for this conference, and as it enters its fourth year, he is still involved in the planning each summer and fall. The conference was an immediate success, and has continued to grow to the point where there were over 150 attendees last year, and many applicants had to be rejected for lack of space.

In the 18 years that Dr. Hughes has been on the faculty at James Madison, he has demonstrated a desire to be innovative in his teaching, to create an environment of discovery for himself and his students, to work across disciplines and institutions to integrate knowledge, and has demonstrated a love of his community that leads him to service to those around him.

PERSONAL STATEMENT

At the beginning of my senior year of high school, our honors English teacher showed our class the Academy Award-winning short film *Why Man Creates*. A mixture of live action and animation, of whimsy and sincerity, the film tries to make viewers consider each person's individual creative process and the emotions that go with it. As an immature 17-year-old, I recall my reaction to the movie being something we only seem to recently have created the right word for: snark. However, on more than one occasion in the last few years as I have thought about what I have done and will do with my career, I've come back to that film. Now the question that intrigues me is not just why does a person create, but how?

Creativity is the intersection of intellect and the human spirit. It takes the framework that the physical world provides us and allows us to make it personal. A large number of the students I encounter in teaching and mentoring undergraduates every day don't yet see creativity as a part of their education. They feel that education is simply an accumulation of facts and an acquisition of skills. My job as a college professor is to change this outlook. I want them to see education as a way of becoming a creative individual in whatever discipline best fits them and then take that creativity out into the world to actively make it something new.

This transformation of the mindsets of students is not easy, but there are methods I have developed throughout my career that work. First and foremost is involving the science students I encounter in undergraduate research. Undergraduate research means taking the teaching role of the professor beyond the classroom and into the lab so that students learn through their own process of discovery. For these students, the classroom is important, but only in the same way that the locker room and practice court are important to a basketball player. When I can help them see that those hours spent in introductory survey classes, or even upper level mathematically intense physics courses, are meant to facilitate their work in the lab, they see that these foundations are the tools for them to be creative and independent scientists. I was a product of undergraduate research experiences myself, and I know that there is a change in your self-identity when you realize that you have observed something no one else has or that you have come up with a new way of observing or modifying the natural world that has never before been done. Teaching, or at least some old-fashioned notion of teaching merely content delivery, is effete to me. Teaching is only alive when it is connected to the engagement and application that happens when students work on original research. This is important to me. It is so important that I have dedicated a large service portion of my career to equipping and supporting this activity at JMU. This includes not only my own work of successfully acquiring external funding for my particular research projects, but also my leadership of programs at JMU, such as leading an NSF-funded Research Experiences for Undergraduates program for nine years and the interdisciplinary Center for Materials Science. Even beyond JMU, I have invested significant time and effort into my leadership roles with the Council on Undergraduate Research (CUR), which is a national organization with over 10,000 members for the advancement of undergraduate research.

One of the great benefits of undergraduate research is that it makes the **student realize the importance of being the initiator of questions**. Experiments happen only because some realize what they don't know and then attempt to lift nature's veil. I have worked hard to bring this same attitude into the classroom where I teach. In my ideal class, I would walk into a room full of students who met me at the door asking, "How do I do this problem?" or "I thought I understood this when I first read it, but I don't quite get it now." I want a class where the learning starts with the students' questions. Just like in the research lab, the forward movement of learning happens only when the students are first aware of what they don't know and then ask questions. This is what I see as my job as a teacher. It is not about being the smartest person in the room. It is not being the repository of information that in this day and age could actually be found on Wikipedia. It is being the coach who puts the students in the position where they see

what they need to do to grow, enquire, and eventually create their own understanding of the world. I've attempted to do this by minimizing the amount of time that I actually lecture in a class. Lecture for me is reserved for those moments when the whole class needs to be told one or two things to bring them all back into synchrony. Instead, I fill my class with active learning as much as possible. What has traditionally been considered lecture material—strictly content delivery—I now put outside the classroom. Let the students do this work in their own time and in the way that best suits each individual. It may be reading; it may be watching videos; it may even be talking to friends. One way or another, when they come to the classroom, they will be involved in an active, engaged learning environment where they will be the prime movers of the learning process. Students frequently expect to be told just the facts that they will repeat back. Therefore, there are many students who initially object to this style of teaching. In fact, one of the comments on a student course evaluation that I am most proud of was certainly intended to be an insult. When asked whether I was a good teacher, a student in an introductory calculus-based physics course last year responded, "I don't know. I had to teach myself everything."

However, I was not hired only to teach physics and chemistry majors, nor would I find joy in a job that only allowed me to interact with those students no matter how much I love and value them. I have taught almost every course that the physics department at JMU offers with the exception of the astronomy courses and some electronics labs. This means I have taught all the versions of general education science courses that we currently offer. This includes teaching pre-service teachers in a hands-on, integrated lab/lecture course in which I developed tools for teaching chemistry and physics principles by analogy or even through card games. But perhaps the most enjoyable general education courses I have taught have been the ones in which I **mixed in my love of arts, history, philosophy, and even some theology to make the science meaningful to students who don't quite understand why they have to learn about it** by meeting them in their own field of interest. While I have little if any talent in music or dance, I have found that the integration of knowledge of physics with arts is exciting for both the scientist and the artist. I have taught the science of light and sound to art and music majors on more than a half-dozen occasions, and each time I come away knowing something more about how a musician approaches his instrument or a stage designer creates a mood with light and color. I've learned so much from these students, and it always begins with me revealing to them a way of looking at sound or color as a scientist does. This opens a dialog about how that matches with their experiences as artists. In a similar way, I have been greatly enriched by teaching a "Physics of Dance" lab course. I think that exposing myself to these students as a novice in their fields makes them more comfortable being a novice in mine. They feel like they can teach me something and therefore don't feel inferior when they come to me to teach them something about the way a physicist views the world. I also get the chance to show them that good science is just as creative as good art. It is inquisitive and inventive within a set of definitions and rules, much like great music is original but follows the traditional scales, or great dance is innovative but uses established steps and movements.

A few years ago when JMU was preparing for accreditation, groups were formed on campus to propose quality enhancement programs (QEPs). I was asked by colleagues to be the science representative in proposing a QEP related to creativity. I think many of the other team members thought this made me, an experimental physicist, a bit of a fish out of water. Instead, I thought back to *Why Man Creates*. The tools may be different, but just as the dance or music professor teaches students to use creativity to communicate their experience of the world around them to others, a scientist teaches students to experiment, observe, and translate the physical world into something others can grasp. A musician spends her time in front of a music stand with her instrument, and I put students in front of the observable world with their knowledge of physics to do that most human thing of all: to make something new.

William Christopher Hughes
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Education

Bachelor of Science with Honors in Physics

- Davidson College (May 1988)
- Thesis: "The Second-Order Elastic Constants of AgCl From 20ºC to 425ºC."

Doctor of Philosophy in Physics

- University of North Carolina at Chapel Hill (October 1993)
- Thesis: "Indium, Hydrogen, and Vacancy Defects in II-VI Semiconductors."

Employment

Director, Center for Materials Science, James Madison University (2008 – present)
Interim Director, Center for Materials Science, James Madison University (2004-2008)
Professor, Dept. of Physics and Astronomy, James Madison University (2010 – present)
Associate Professor, Dept. of Physics and Astronomy, James Madison University (2002-2010)
Assistant Professor, Dept. of Physics, James Madison University (1997-2002)
Post-Doctoral Research Associate, Dept. of Physics, N. C. State University (1994-1997)

Honors and Awards

JMU College of Science and Mathematics Madison Scholar for 2015
JMU College of Science and Mathematics Distinguished Service Award for 2012
JMU College of Science and Mathematics Outstanding Teacher Award for 2008

Grant Awards

"RUI: Modification and Characterization of Polymer Surfaces with Applications in Microfluidic Neural Circuit Development," National Science Foundation, 6/1/13 - 5/31/16, $313,186.
"An Interdisciplinary Materials Science REU Program at James Madison University," National Science Foundation, 3/1/09 - 2/29/12, $267,063.
"RUI: Polymer Nanocomposite Surface Modification and Characterization for Microfluidic Applications," National Science Foundation, 4/1/08 - 3/31/09, $55,000.
"RUI: Physico-Chemical Characterization and Processing of Nanocomposite Polymers for Microfluidic Applications," National Science Foundation, 4/1/04 - 3/30/07, $230,000.
"An Interdisciplinary Materials Research REU Site at James Madison University," National Science Foundation, 3/1/04 - 2/28/07, $202,655.
"Edge Characterization and Quantification of Stainless Steel Specialty Blades Using Scanning Microscopy," Center for Innovative Technology, 7/1/02 - 9/30/02, $4,500.
"Acquisition of a Scanning Electron Microscope/Energy Dispersive Spectrometer for Materials Investigation and Student Training," National Science Foundation, Division of Materials Research, 7/1/01 - 8/30/04, $287,085.
"Acquisition of Large Stage Atomic Force Microscope for Undergraduate Teaching and Research," National Science Foundation, Division of Materials Research, 6/1/01 - 5/31/02, $118,745.
"Equipment for an Undergraduate Microfabrication Laboratory," National Science Foundation, Division of Undergraduate Education (CCLI), 5/1/01 - 4/30/03, $87,075.
"A Materials Science REU Site at James Madison University," National Science Foundation, Division of Materials Research, 3/1/01 - 2/29/04, $150,000.

"JMU Summer Research Outreach Initiative," GTE Foundation, 5/1/00 - 5/1/02, $30,000.
"Electrochemical Reactions Involving Wide Band-Gap III-V Nitride Semiconductors," Research Corporation, 9/1/99 - 8/31/01, $59,202.
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LETTERS OF SUPPORT (EXCERPTED)

Steven Whisnant, Head, Department of Physics, JMU

Dr. Hughes has played a key role in leading the Department of Physics and Astronomy at James Madison University (JMU) since joining our faculty. As a leader in materials science, he has brought us national visibility through his activities in the Council on Undergraduate Education (CUR) and the Materials Research Society (MRS). He helped initiate the National Science Foundation (NSF) funded summer materials summer research program for undergraduates (REU) at JMU and led this program for well over a decade. In the classroom and the laboratory, Dr. Hughes has mentored dozens of students, guiding them to careers as productive citizens and excellent scientists, engineers, lawyers, and physicians. He serves as the director of the Center for Material Science (CMS) providing support to multidisciplinary collection of researchers in the field. From this position, Dr. Hughes has nurtured a vibrant and well-funded program of engaging JMU undergraduates in a wide variety of research experiences.

Dr. Hughes's contributions to our academic excellence have been significant and continue to shape the future of our program. He has taught nearly every course the department offers and, by all reports from both peers and students, he excels in all settings. He is a leader in the reform of our calculus-based introductory physics classes and is now taking on the task of applying what he has learned to the reform of the algebra-based courses. He was the pioneer in our department for including undergraduate upper-class students in the classroom at his side teaching introductory students. He has changed the way we view these courses and, more importantly, the way the students in those courses see their role in the learning process.

In addition to his outstanding research and teaching contributions, Dr. Hughes is a respected leader in our department. He prepares the teaching schedules and ensures that all our students have the learning opportunities they seek. His guidance as the director of the CMS is recognized across the college. His contributions to the education of undergraduates through CUR and MRS are appreciated across the university. Dr. Hughes's service to our institution has been critical to our success at every level.

The impact Dr. Hughes has had on our department and college is made clear by noting that he is one of only two people in the history of the JMU College of Science and Mathematics to have earned the college's highest accolade in all three areas of research, teaching, and service. His many publications and patents, his early guidance of the many now-successful scientists, his leadership in teaching reform, and his leadership in materials science at both the local and national levels, have made him invaluable to our institution and his field.

A research-intensive institution would rely more on his excellence in scholarship and a smaller liberal arts college would more appreciate his ability to innovate in the classroom and connect with the students. At JMU, where research, teaching, and service place comparable roles in the maturation of our students, Dr. Hughes's many talents have enabled him to move the university's mission forward on all fronts. His rare set of abilities has enabled him to play a critical role in the success of our department, our college, and the university.

Caitlin Hawes, former student

Dr. Hughes was one of the most engaging professors that I have ever had. His self-deprecating humor and concise explanations made the information easy to comprehend. He is not only highly intelligent, but he can effectively communicate the concepts in a way that is easy to understand. As an undergraduate math major, I didn't have too much trouble with the math part of physics; my struggles came more with wrapping my brain around the concepts in order to apply the math. Dr. Hughes was always willing to meet outside of class to help me further comprehend the concepts. He would show me the beginning of a problem, so that I would know where to start, and then boost my confidence with his encouraging words. He was always willing

to pause class and be flexible with the material, particularly if we were having trouble grasping a difficult topic.

Dr. Hughes took the initiative to try teaching our Physics 250 course in a different way. He would assign several homework problems each day, but then split the class into homework sessions where he would sit down with small groups of us for an additional hour one day a week to go over the problems. It was our responsibility to work the problems prior to coming to the session, but if we were stuck on one, he would assist us or walk us through the steps to solve the problem. While this was an extremely time consuming task for him, it showed his willingness to try a new method to improve student learning. Not only was this an effective method for us, but it truly helped everyone in the class perform better. Few teachers are this service-oriented and student-centered. It is very encouraging as a student to see teachers working hard to help us learn more effectively.

Marilou Johnson, JMU Vice Provost for Academic Development

Over the last decade there has been a national focus on the STEM fields. When the College of Visual and Performing Arts was created in 2005, we set a goal to find ways to integrate the arts with disciplines from across campus, including the science and technology areas. In order to be successful, we needed champions from outside the arts who recognized the importance of embracing the artist's creative process as complementary to the scientist's mode of discovery. On our campus, Chris Hughes was one of our most valued champions. As a gifted physics teacher, he was already an innovator in the classroom. All he needed was a conversation with dance faculty to formulate the idea for interdisciplinary learning experiences bringing together dance students and physics students to study motion and kinetic energy. He models the love of discovery and an enthusiasm for learning in all of his work.

Cynthia Thompson, JMU School of Theatre and Dance Associate Director and Dance Program Coordinator

The Physics of Dance Lab conceived and taught by Dr. Hughes is a true example of integration and sustainability. The course is extremely popular with dance majors, not only because they are fascinated with the information, but because the effective and clear teaching of Dr. Hughes allows the dancers to improve their understanding of the body and how it works in relation to specific applications in both contemporary and ballet technique. They apply the knowledge gleaned from the course, and their technique improves. Talk about a win-win situation! Dr. Hughes has designed the lab so that the students in the course observe the last 30 minutes of the advanced technique class that I am teaching that particular semester. The lab meets immediately following and the observations from the technique class became the subject matter of the lab. Because I repeat material from class to class, we often bring the information from the lab work directly into the technique class. This class design allows for deep learning on the part of students in my technique class, the lab students, as well as Dr. Hughes and myself. This organic and free flow of information is what effective integration is all about. It creates an environment of excitement in the classroom and benefits everyone in the room. The direct integration of science into the dance classes enriches the student knowledge base and benefits them as dancers and teachers of dance. Another beauty of this course is that the dance program benefits from it without additional resources. It is a great gift.

Brian Augustine, Chair, Department of Chemistry, High Point University

Chris and I were hired in 1997 to help develop a materials science program at JMU. The Center for Materials Science had been established the prior year, but it was our arrival that was the catalyst for the development of a concentration and minor in materials science and a focused undergraduate research program in materials. We co-developed an introductory course in materials (CHEM / PHYS 275) that has become a foundational course in the College of

Science and Mathematics at JMU for students wishing to pursue interests in materials science, and is a prerequisite for any subsequent materials or nanoscience courses.

After our arrival, interest in materials science grew at JMU, and there are nearly a dozen faculty members across several departments with interests in materials, and typically 5 to 15 students graduate each year in chemistry and physics with either a minor or concentration in materials science. JMU's undergraduate program in materials science is now considered a model program for primarily undergraduate institutions hoping to introduce cross-disciplinary teaching and research between chemistry and physics. It is no accident that Chris is the director of the Center for Materials Science, as his leadership has helped to make the program strong.

He was also the lead PI on the National Science Foundation Research Experiences for Undergraduates (NSF-REU) program in materials science from 2002 to 2009. This program was unique in that most REU programs are awarded to PhD-granting institutions, and there are only a handful of these programs at primarily undergraduate programs. The program provided for nearly a dozen undergraduate summer research stipends per year, and included two international students per year, which really enhanced the quality of the program. In fact, two of these students were South African women who are now pursuing doctoral studies, breaking the traditional barriers for female Zulu students. Both are destined to become leaders in South African science in the years to come.

In the research laboratory, Chris and I have had a very productive collaboration over the years, having mentored nearly 70 undergraduate students. Many of our undergraduate research students have gone on to top-tier graduate programs, including PhDs awarded from Cornell, UNC-Chapel Hill, Johns Hopkins, Northwestern, Georgia Tech, UC Santa Barbara, UC Davis among others. His knowledge of machining and fabrication, coupled with his creativity and problem solving skills, have led to many breakthrough moments over the years in the laboratory. He is adept at trying ideas that at first blush sound a little crazy, but with a little refinement are often the key to unlocking a difficult problem. We have coauthored eight publications in high impact factor surface science and materials education journals over the years, and the saying "the sum is greater than the parts" is very applicable in that without collaborating, it is unlikely that most of the results that were published would have ever been completed.

Elizabeth L. Ambos, Executive Officer, Council on Undergraduate Research

On behalf of the Council on Undergraduate Research (CUR), it is a distinct pleasure and a privilege to write in support of W. Christopher Hughes' candidacy for the Outstanding Faculty Award. In addition to witnessing Chris' meaningful contributions as a Councilor in the Division of Physics and Astronomy, I have had the opportunity to work with Chris over the past three years on a project of significant national interest: showcasing the research achievements of students engaged in National Science Foundation Research Experiences for Undergraduates (NSF-REU) programs. Chris was one of a small group of committed teacher-scholars who envisioned the symposium, and made it happen. The annual CUR NSF-REU symposium is now a thriving event, in no small part due to Chris' thoughtful leadership. In addition to Chris' contributions to building a national presentation presence for NSF-REU, he has been an ambassador to connect CUR with the Materials Research Society, co-organizing a special session at the 2014 meeting focusing on the impacts and benefits of undergraduate research in materials science. Last but not least, and on a personal note, I find Chris to be an exceptional colleague: deeply committed to his research and his students, highly approachable and positive in his interactions, and adding a lot to any conversation or group with which he comes in contact.

ADDITIONAL DOCUMENTATION

Excerpts from Student Comments in Course Evaluations

"As a senior, I was much more focused on my capstone classes in my major and I have never understood science at all, but Professor Hughes made the class an enjoyable experience. He is genuinely fascinated with science and I really respect his dedication to his students and his teaching. I imagine that it is difficult to teach GSCI101 students, especially when many of them are not interested in the materials and I think he did a fabulous job." – student in GSCI 101: Physics Chemistry and the Human Experience

"Professor Hughes is always available to help his students. I really appreciate it when professors make themselves available to answer question and help you understand the material. Also, it can sometimes be intimidating to ask for help but Professor Hughes always welcomed questions. I also liked that he put learning objectives up on blackboard, which helped me study for tests and I liked that he put up answer keys to previous assignments and tests on blackboard, which also helped me study. Overall, Professor Hughes is committed to helping his students be successful." – student in GSCI 101: Physics Chemistry and the Human Experience

"Professor Hughes is a phenomenal teacher and the best one I've ever had at JMU" – student in GSCI 121: The Science of Light and Sound

"Dr. Hughes was a great teacher, for a class that is an hour and a half, I wasn't ever too bored because he had good hands-on activities that kept us going" – student in GSCI 163: The Matter of Matter

"He is fantastic about asking extra questions to really understand material presented." – student in PHYS 397: Biophysics

"He obviously cares about his students and is willing to go above and beyond to make sure we understand. He leaves the ball in our court, however, to make sure we understand the material which instills responsibility in the students." " – student in GSCI 121: The Science of Light and Sound

"Dr. Hughes is a great professor and, if I weren't a Senior, I would consider switching my major because his passion for the subject and his students in contagious, especially for a class meant for people who have most classes on the Quad!" " – student in GSCI 121: The Science of Light and Sound

"I'm a senior, & Dr. Hughes is one of the best teachers I've ever had at JMU. I can't even begin to express how much effort & enthusiasm he puts into teaching. He went above & beyond every day to be engaging & interesting to help us understand better." " – student in GSCI 121: The Science of Light and Sound

"Dr. Hughes took an average Gen Ed and made it an enthralling educational experience." " – student in GSCI 121: The Science of Light and Sound

Links to Videos Produced for PHYS 240 Flipped Classroom

Title	Link	Title	Link
Units	youtu.be/jhytM3vYXZk	Work By Varying Forces	youtu.be/TjBUKzCeBFw
Converting Units	youtu.be/YhI_6MLeLOw	Springs	youtu.be/kcJfgjdqCoQ
Vectors	youtu.be/PiXuno-ZvL4	Power	youtu.be/uuaYWzsR97s
Adding Vectors	youtu.be/637D-hcfYfE	Conservative Forces	youtu.be/UWOGlAl1Kvo
Mulitplying Vectors	youtu.be/Ix7HG9iHZFU	Potential & Kinetic Energy	youtu.be/fG2SwhMFaVg
Position, Velocity, & Acceleration	youtu.be/0Nfwzrokps0	Elastic Energy	youtu.be/hQa8y5EF3rc
Kinematics	youtu.be/fqu11RhC0EA	Non-conservative Forces	youtu.be/8bINdH4T4kQ
Graphical Analysis	youtu.be/PpKPai_rloE	Graphing Energy	youtu.be/eyL8wHbBaXE
Constant Acceleration – I	youtu.be/DMhtFQzLIPM	Acting on Impulse	youtu.be/1IRe3Aa6xks
Constant Acceleration - II	youtu.be/cnC1a8PmuYM	Conserving Momentum – I	youtu.be/m3C-fgdXVAU
Free Fall	youtu.be/y6AHVwF_gmM	Conserving Momentum – II	youtu.be/aUNSbQQom3Y
Motion in More Than 1-D	youtu.be/OlPvl-rjlPk	Conserving Momentum – III	youtu.be/jLEe3sS_wYg
Projectile Motion	youtu.be/d12AyZten6I	Conserving Momentum – IV	youtu.be/pwkhpRvr-jQ
Trajectory & Range	youtu.be/NnY2T25Pyxo	Bouncing & Momentum	youtu.be/k5l9ZxPj2mw
3-D Motion	youtu.be/JSUOV3vViYM	2D Momentum	youtu.be/nWFCXY0o-_4
Relative Motion	youtu.be/jGMKEhuC3R8	Explosions	youtu.be/XzzHxLbCS-o
Newton's Laws	youtu.be/G9HuElm4iKo	Center of Mass	youtu.be/ov3v39XKlDU
Forces	youtu.be/wlWhPWRMiZk	Motion of the Center of Mass	youtu.be/JcCQAYIzpuM
Apparent Weight	youtu.be/EnkPM08bgjI	Moving in Circles	youtu.be/y3DwSjlf87I
Friction	youtu.be/Uluu2S-g7b4	Angular Variables	youtu.be/rI-pNoh1PE8
Tension	youtu.be/Zno75Ml4Cds	Centripetal Forces	youtu.be/YI1oe65xBZE
Free Body Diagrams	youtu.be/tK2uMTm2fo8	More Centripetal Forces	youtu.be/gus-sIxtOcQ
Free Body Diagrams	youtu.be/vscC9Zq1CG4	Turning Corners	youtu.be/_q9XzFZCTSA
Atwood's Machine	youtu.be/jjgInwlT19U	Rotational Energy	youtu.be/dQjgYrura9g
Simple Machines – Inclined Plane	youtu.be/JccO66EKqw0	Moments of Inertia	youtu.be/sphrvu-YajM
Simple Machines – Pulley	youtu.be/6C_Falqtl_0	Rolling Motion	youtu.be/VPqG9MDInvw
Pushing vs. Pulling	youtu.be/7Ma3MyLnHdM	Rolling Downhill	youtu.be/Mp7-U3H_0vc
Work & Energy	youtu.be/-gdYcwELhfo	Torque	youtu.be/oBSrZmoKK5M
Work & Gravity	youtu.be/U63gYA2qNU4	Balancing Torques – I	youtu.be/0Ir0VYMv6NQ
Work By Varying Forces	youtu.be/TjBUKzCeBFw	Balancing Torques – II	youtu.be/YRavnHQ2SRo

Title	Link	Title	Link
Conserving Angular Momentum – I	youtu.be/qXZE0bCV1Pk	Standing Waves	youtu.be/y8FvXiT4z0g
Conserving Angular Momentum – II	youtu.be/3KUoygjZJ24	Superposition	youtu.be/8QF-rEzdHLg
Angular Momentum (Linear Case)	youtu.be/4YMPAlFOJBM	Power and Energy in Waves	youtu.be/vWe991DmmDM
Simple Harmonic Oscillation – I	youtu.be/qtrof_NFenc	Sound Waves	youtu.be/bFAdII2Pbxg
Simple Harmonic Oscillation – II	youtu.be/Lqrb33Ujc3k	Doppler Effect	youtu.be/EGi_kgB8TSg
Energy in Simple Harmonic Motion	youtu.be/ThpUzXGU8oA	Beats	youtu.be/5MFr6P4rltE
The Simple Pendulum	youtu.be/ZJ63TdiOGHc	Density and Pressure	youtu.be/SeRDtSru980
Damped Oscillators	youtu.be/yjCNi-DnKx4	Pressure and Depth	youtu.be/Fh7YlvIgBhQ
Driven Oscillators	youtu.be/rEE_Y24G8S0	Archimedes' Principle	youtu.be/hWl3-n0cScs
Making Waves	youtu.be/Xxtn3V1NiKs	Moving Fluids – Continuity	youtu.be/k0Qq6kvHopM
Wave Speed	youtu.be/zlERXmuEdJo	Moving Fluids - Bernoulli	youtu.be/kB24JqdY_Po
Wave Reflections	youtu.be/EPEdOjbRCp4		

Cover Page of Patent Awarded in 2008

US007381471B2

(12) **United States Patent**
Augustine et al.

(10) **Patent No.: US 7,381,471 B2**
(45) **Date of Patent: Jun. 3, 2008**

(54) **HYBRID POLYMERS FOR FUNCTIONAL TUNING OF MICROFLUIDIC DEVICE SURFACES**

(75) Inventors: **Brian H. Augustine**, Bridgewater, VA (US); **James P. Landers**, Charlottesville, VA (US); **Jerome P. Ferrance**, Charlottesville, VA (US); **Joy M. Polefrone**, Charlottesville, VA (US); **W. Christopher Hughes**, Harrisonburg, VA (US)

(73) Assignees: **University of Virginia Patent Foundation**, Charlottesville, VA (US); **James Madison University**, Harrisonburg, VA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 503 days.

(21) Appl. No.: **10/520,763**

(22) PCT Filed: **Jul. 15, 2003**

(86) PCT No.: **PCT/US03/22162**

§ 371 (c)(1),
(2), (4) Date: **Jan. 10, 2005**

(87) PCT Pub. No.: **WO2004/007582**

PCT Pub. Date: **Jan. 22, 2004**

(65) **Prior Publication Data**

US 2006/0057402 A1 Mar. 16, 2006

Related U.S. Application Data

(60) Provisional application No. 60/399,633, filed on Jul. 30, 2002, provisional application No. 60/396,153, filed on Jul. 15, 2002.

(51) **Int. Cl.**
B32B 25/20 (2006.01)

(52) **U.S. Cl.** **428/447**; 428/451

(58) **Field of Classification Search** 428/447, 428/451

See application file for complete search history.

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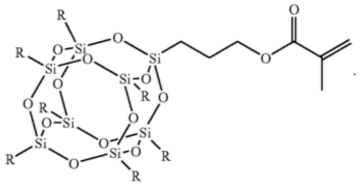
(57) **ABSTRACT**

The present invention is directed to improved microdevices and methods of manufacturing such devices. More particularly the present invention is directed to the use of a compound having the general structure (formula (I)): wherein R is selected from the group consisting of C_1-C_6 alkyl, C_2-C_6 alkenyl, C_2-C_6 alkynyl, C_3-C_8 cycloalkyl, and C_5-C_6 aryl for bonding silica based substrates to plastic substrates or to other silica based substrates. In addition the polymer can be used to coat microchannels to enhance the physical properties of the microdevice

(I)



19 Claims, 2 Drawing Sheets