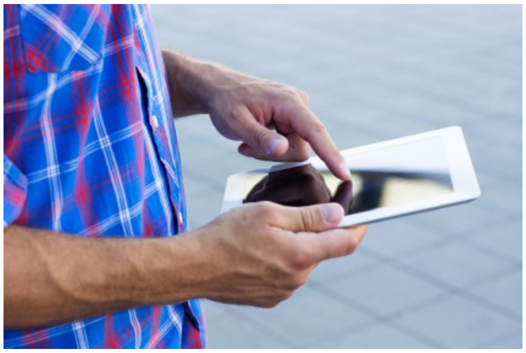
Materials Engineering

Starting salary: $62,000
Median income: $85,150



Materials engineers design, fabricate, and test materials. They may work to make automobiles lighter and more fuel efficient by creating stronger and lighter metals. They may help to create artificial knees and elbows using special polymers, or they may design new materials for the next rocket into space.

A materials engineer can work with any type of material – plastic, wood, ceramic, petroleum, or metals – and create completely new synthetic products by rearranging the molecular structure. For example, Teflon (polytetrafluoroethylene), the product that coats millions of cooking pans, was invented by freezing and compressing a gas related to refrigerants.

Materials engineers have numerous career opportunities available to them. Materials can lead to a career in the transportation industry, for example, working to design more fuel-efficient cars, trains, boats, and buses. Special lubrication products can be designed for race car suspensions and high-strength alloys for space travel. Materials engineering can also lead to a career in communications. Semiconductor companies employ materials engineers to develop silicone to speed up computers by allowing faster transport of electronic signals. New and purer forms of germanium, cesium, tungsten, and copper used in electronic components also need to be developed to lower the cost and increase the stability of all electronic components and systems.

As stated on the San Jose State University materials engineering department website, “The percentage of materials engineers in the total of all engineers in the engineering profession is small: probably less than 5 percent. However, the need to apply basic materials principles to the solution of engineering problems is great. Certainly in today’s high-tech society basic materials principles must be applied to almost all endeavors: thermal protection of the space shuttle; creation of the

Job Outlook

Employment of materials engineers is projected to show little or no change from 2012 to 2022. Materials engineers will be needed to design uses for new materials both in traditional industries, such as aerospace manufacturing, and in industries focused on new medical or scientific products.

Industries with the highest levels of employment in this occupation:

1. Aerospace product and parts manufacturing
2. Architectural, engineering, and related services
3. Scientific research and development services
4. Semiconductor and other electronic component manufacturing
5. Federal government, excluding postal service

Top paying industries for this occupation:

1. Federal government, excluding postal service
2. Aerospace product and parts manufacturing
3. Scientific research and development services
4. Semiconductor and other electronic component manufacturing
5. Architectural, engineering, and related services

Source: US Bureau of Labor Statistics

artificial hip; design of the titanium golf club; and production of advanced battery systems for the electric car, the artificial heart, and the laptop computer. Industry and government have traditionally depended on a few individuals on a project to address, for example, materials selection and process issues (i.e., a titanium, stainless steel or plastic artificial hip; which alloy; which fabrication sequence; a protective coating for corrosion and wear). Without the benefit of a materials education, these individuals rely on handbook information, experience and vendor data to select materials and to determine the processing sequence. The B.S. degree in materials science and engineering teaches the inter-relationship between structure, properties and processing; factors which determine the in-service performance and durability of a component or product."

Smart Engineering

Smart engineering doesn't have so much to do with being a smart engineer as it does to creating smart structures or materials with a brain. "What does that mean?" you may ask. Think about the last time you saw the downhill ski competition in the Olympics. Do you remember how fast those skiers were flying? Do you remember watching their skis scream right through all that powder or watching in horror as the ice-packed snow sent a contestant toppling down the hill at 70 m.p.h.?

What if you could make a difference in the performance of the Olympic participants? What if you could improve skiers' performance, making them faster by allowing more control? What if you could create a product that allowed professionals to break the current world records?

To give you some background, let's talk about what it takes to design skis. Ski designs vary to accommodate different environmental conditions. Longer skis provide more stability and allow for more control at higher speeds, while shorter skis are better for turning in any condition because there is less ski to manage. However, short skis also have a tendency to vibrate and cause a loss of control. Wider skis distribute your weight over a larger area and are therefore better for soft powdery snow. To ski on hard-packed snow, a rider wants an hourglass ski that digs deeper and makes sharper cuts.

If the sporting goods industry is your destiny, smart materials technology may be your ticket. Smart skis use piezoelectric devices (special sensors) to detect vibration and act like a shock absorber, thereby getting rid of vibration. With less vibration, skiers can control their rides better and are thus able to go faster and make quicker turns. The sensors acts like the human body's nerve endings, except the sensors absorb vibration and convert the shock or vibration into electrical charge. A tiny control circuit then releases the energy through heat and light, eliminating vibrations. With reduced vibrations, more of the ski stays in contact with the snow; the result is greater stability, higher speed, and smoother riding.

For example, when you ride in a car you have optimum control over the vehicle when all four tires are on the road. If you make a turn very fast and two tires come off the road, you have lost control and are probably holding on for dear life. A professional race car has very wide tires to enable more traction and keep the driver in full control at the fastest possible speed. The same theory holds true for amateur and professional skiers: you have the most control when the entire surface area of the ski is touching the snow.

How does it work?

Piezoelectric devices, the sensors that make a snowboard smart, have the unique ability to detect a shock or vibration and convert it into an electric charge. The piezos are manufactured right into the snowboard. On hard-packed snow, snowboards are especially prone to vibration. These vibrations lessen stability, control, and overall performance.

The piezo control module takes the mechanical energy produced from the vibration and converts it into electrical energy. The electrical energy is applied across a shunt circuit that transforms it into heat and removes it from the board to reduce the vibration. Look at it this way: If you have $300 and then buy a snowboard, you now have a snowboard instead of $300. If you have vibration and trade it for heat, you now have heat instead of vibration. The vibration is gone and the heat is simply transferred out. The applications of smart engineering are limitless and will change the way we live.

Currently, smart materials are also used in other sports equipment such as baseball bats, water skis, and mountain bikes. Any sport you can think of where less vibration would increase performance is a market for smart materials. It is being used in building design to accommodate mother nature's fury. Even smart clothes have hit the scene.

Smart Structures

The multidisciplinary field of smart engineering comprises scientific knowledge about materials, sensors, constructions, electronics, mechanics, and information processing. Smart materials are defined as materials that react and modify their reaction because of changes in the environment – like the smart skis, snowboards, and mountain bikes discussed earlier. Smart structures are understood as the system of sensors and actuators that keep the structure in a current state (standing upright) or aid the structure's reaction to a particular event (hurricane winds).

If we want to have a smart structure, we have to make it smart. For example, suppose you are the lead civil engineer on a bridge project. As the engineer responsible for the safe transportation of millions of people every week, you want to know when the bridge shows any signs of decay, deterioration, or damage.

Smart technology can do just that. Sensors can be embedded in the concrete structure to sense changes in pressure and signal when structural damage may occur. Any structure that undergoes a lot of wear and tear is a potential applicant for smart technology. Engineers hope to save both time and lives with smart structures that warn the operator or designer when weak spots present a potential disaster.

Eventually, earthquake resistant structures will also be possible. A smart structure will sense an earthquake and the building materials will actually alter their stiffness in response to the movement of the earth. Smart structures will shake the building in the opposite direction of the earth's movement and thereby cancel out the effects of the quake.

Other Smart Stuff

Other applications for smart materials include space structures, airplanes, helicopters, submarines, the sound industry, the automobile industry, and artificial muscles, and more. Anything that can be improved by increased performance, greater stability, or decreased maintenance is a candidate for smart technology.

Space Structures – Large space structures are subject to a variety of disturbances by the crew, the docking of other spacecraft, temperature changes during the orbit, and tiny meteorites. Smart materials can damp the vibrations of the disturbances to avoid instability and achieve optimum control in the space structure.

Airplanes – Airplanes that have smart materials embedded in their bodies will have control surfaces that can reshape themselves in mid flight. With the help of the smart structures airfoil, the shape and lift of the aircraft will be improved. A single-engine fighter could fly off the deck of an aircraft carrier without a catapult when this technology becomes available. Lightweight and high performance smart materials could double an aircraft's flight range and require 30 percent less fuel.

Helicopter Blades – Helicopter blades can adjust their shape continuously to respond to air-pressure changes that cause vibrations. Those fluctuations knock the machinery out of alignment and cause a helicopter to require excessive maintenance. Piezoelectric patches on the blade surfaces can function as both sensors and actuators, or generators of counter-force.

Submarines – Smart materials technology may result in stealth submarines. Their smart skins would detect the pressure of an incoming sonar wave and automatically generate an equal but opposite counter pressure that would cancel out the ping. With nothing reflected back to the enemy boat, the submarine would be invisible.

Auto Industry – The automotive industry incorporates intelligent materials technology in projects such as smart car seats that can identify primary occupants and adapt to their preferences for height, legroom, back support, and so forth. Smart materials will also lead to new kinds of suspensions and transmissions.

Sound Industry – Speaker research is aimed at turning whole house walls or car interiors into speakers by embedding them with tiny actuators. Fifty years from now people won't need to install separate speakers in their homes and cars in an attempt to achieve dramatic sound effects. Their cars and houses will offer built-in surround-sound.

Artificial Muscles – Smart materials that expand and contract similar to human muscles have already been embedded in prosthetic arms and could find numerous applications in robotics, medical implants, and virtual reality.

The field of smart materials is growing rapidly and may be an exciting way to stay on the cutting-edge of technology for many years to come.

More information about materials engineering can be found at the Society for Biomaterials website at www.biomaterials.org, the Materials Engineering and Sciences Division of the AIChE site at www.aiche.org, the Materials Engineering Division of the ASCE site at www.asce.org, and the Materials Division of the ASME site at www.asme.org.

Glossary of Terms

Alloy – a metal made by melting and mixing two or more metals or a metal and another material together (merriam-webster.com)

Communications – the ways of sending information to people by using technology (merriam-webster.com)

Component – one of the parts of something (such as a system or mixture): an important piece of something (merriam-webster.com)

Compress – to press or squeeze (something) so that it is smaller or fills less space (merriam-webster.com)

Design – to plan and make (something) for a specific use or purpose (merriam-webster.com)

Fabricate – to construct from diverse and usually standardized parts (merriam-webster.com)

Fuel Efficient - producing power at a rate that is optimal with regard to the amount of fuel used by the vehicle (Dictionary.com)

Lubricate – to make (something) smooth or slippery : to apply a lubricant to (something, such as a machine or a part of a machine) (merriam-webster.com)

Molecular Structure – The location of the atoms, groups or ions relative to one another in a molecule, as well as the number and location of chemical bonds (biology-online.org)

Polymers – a chemical compound that is made of small molecules that are arranged in a simple repeating structure to form a larger molecule (merriam-webster.com)

Product – something that is the result of a process (merriam-webster.com)

Refrigerant – a substance used in refrigeration (merriam-webster.com)

Semiconductor – a material or object that allows some electricity or heat to move through it and that is used especially in electronic devices (merriam-webster.com)

Signal – a detectable physical quantity or impulse (as a voltage, current, or magnetic field strength) by which messages or information can be transmitted (merriam-webster.com)

Suspension – the system of devices (as springs) supporting the upper part of a vehicle on the axles (merriam-webster.com)

Synthetic – made by combining different substances: not natural (merriam-webster.com)

Test – critical examination, observation, or evaluation (merriam-webster.com)

ABET Accredited Programs in Materials Engineering			
School Name	**Location**	**Website**	**Program and Degree Name**
Alfred University	Alfred, NY, US	www.alfred.edu	Materials Science and Engineering, BS
Arizona State University	Tempe, AZ, US	www.asu.edu	Materials Science and Engineering, BSE
Auburn University	Auburn, AL, US	www.auburn.edu	Materials Engineering, BMTL
Boise State University	Boise, ID, US	www.boisestate.edu	Materials Science and Engineering, BS
Brown University	Providence, RI, US	www.brown.edu	Materials Engineering, BS
California Polytechnic State University, San Luis Obispo	San Luis Obispo, CA, US	www.calpoly.edu	Materials Engineering, BS
Carnegie Mellon University	Pittsburgh, PA, US	www.cmu.edu	Materials Science and Engineering, BS
Case Western Reserve University	Cleveland, OH, US	www.case.edu	Materials Science and Engineering, BS
Cornell University	Ithaca, NY, US	www.cornell.edu	Materials Science and Engineering, BS
Drexel University	Philadelphia, PA, US	www.drexel.edu	Materials Engineering, BS
Georgia Institute of Technology	Atlanta, GA, US	www.gatech.edu	Materials Science and Engineering, BS
Illinois Institute of Technology	Chicago, IL, US	www.iit.edu	Materials Science and Engineering, BS
Iowa State University	Ames, IA, US	www.iastate.edu	Materials Engineering, BS
Lehigh University	Bethlehem, PA, US	www.lehigh.edu	Materials Science and Engineering, BS
Massachusetts Institute of Technology	Cambridge, MA, US	www.mit.edu	Materials Science and Engineering, BS
Michigan State University	East Lansing, MI, US	www.msu.edu	Materials Science and Engineering, BS
Michigan Technological University	Houghton, MI, US	www.mtu.edu	Materials Science and Engineering, BS
New Mexico Institute of Mining and Technology	Socorro, NM, US	www.nmt.edu	Materials Engineering, BS
North Carolina State University at Raleigh	Raleigh, NC, US	www.ncsu.edu	Materials Science and Engineering, BS
Northwestern University	Evanston, IL, US	www.northwestern.edu	Materials Science and Engineering, BS
Pennsylvania State University	University Park, PA, US	www.psu.edu	Materials Science and Engineering, B.S.
Purdue University at West Lafayette	West Lafayette, IN, US	www.purdue.edu	Materials Science and Engineering, BS
Rensselaer Polytechnic Institute	Troy, NY, US	www.rpi.edu	Materials Engineering, BS
Rutgers, The State University of New Jersey	New Brunswick, NJ, US	www.rutgers.edu	Materials Science and Engineering, BS
San Jose State University	San Jose, CA, US	www.sjsu.edu	Materials Engineering, BS
The Johns Hopkins University	Baltimore, MD, US	www.jhu.edu	Materials Science and Engineering, BS
The Ohio State University	Columbus, OH, US	www.osu.edu	Materials Science and Engineering, BSMSE
University of Alabama at Birmingham	Birmingham, AL, US	www.uab.edu	Materials Engineering, BS
University of Arizona	Tucson, AZ, US	www.arizona.edu	Materials Science and Engineering, BSMSE
University of California, Berkeley	Berkeley, CA, US	www.berkeley.edu	Material Science and Engineering, BS
University of California, Berkeley	Berkeley, CA, US	www.berkeley.edu	Materials Science and Engineering and Mechanical Engineering, BS
University of California, Berkeley	Berkeley, CA, US	www.berkeley.edu	Materials Science and Engineering and Nuclear Engineering, BS

ABET Accredited Programs in Materials Engineering			
School Name	**Location**	**Website**	**Program and Degree Name**
University of California, Davis	Davis, CA, US	www.ucdavis.edu	Materials Science and Engineering, BS
University of California, Irvine	Irvine, CA, US	http://www.uci.edu/	Materials Science Engineering, BS
University of California, Los Angeles	Los Angeles, CA, US	www.ucla.edu	Materials Engineering, BS
University of California, Riverside	Riverside, CA, US	www.ucr.edu	Material Science and Engineering, B.S.
University of Cincinnati	Cincinnati, OH, US	www.uc.edu	Materials Engineering, BS
University of Connecticut	Storrs, CT, US	www.uconn.edu	Material Science and Engineering, BSE
University of Florida	Gainesville, FL, US	www.ufl.edu	Materials Science and Engineering, BS
University of Idaho	Moscow, ID, US	www.uidaho.edu	Materials Science and Engineering, BS
University of Illinois at Urbana - Champaign	Urbana, IL, US	www.illinois.edu	Materials Science and Engineering, BS
University of Kentucky	Lexington, KY, US	www.uky.edu	Materials Engineering, BSMAE
University of Maryland College Park	College Park, MD, US	www.umd.edu	Materials Science and Engineering, BS
University of Michigan	Ann Arbor, MI, US	www.umich.edu	Materials Science and Engineering, BSE
University of Minnesota - Twin Cities	Minneapolis, MN, US	www.umn.edu	Materials Science and Engineering, BMatSE
University of Nevada, Reno	Reno, NV, US	www.unr.edu	Materials Science and Engineering, BS
University of Pennsylvania	Philadelphia, PA, US	www.upenn.edu	Materials Science Engineering, BSE
University of Pittsburgh	Pittsburgh, PA, US	www.pitt.edu	Materials Science and Engineering, BS
University of Tennessee at Knox-ville	Knoxville, TN, US	www.utk.edu	Materials Science and Engineering, BS
University of Utah	Salt Lake City, UT, US	www.utah.edu	Materials Science and Engineering, BS
University of Washington	Seattle, WA, US	www.engr.washington.edu	Materials Science and Engineering, BSMSE
University of Wisconsin - Madi-son	Madison, WI, US	www.wisc.edu	Materials Science and Engineering, BS
University of Wisconsin-Milwau-kee	Milwaukee, WI, US	www.uwm.edu	Materials Engineering, BSE
Virginia Polytechnic Institute and State University	Blacksburg, VA, US	www.vt.edu	Materials Science and Engineering, BS
Washington State University	Pullman, WA, US	www.wsu.edu	Materials Science and Engineering, BS
Wright State University	Dayton, OH, US	www.wright.edu	Materials Science and Engineering, BS