COMPANIES TO WATCH
IN MATERIALS SCIENCE AND ENGINEERING

INNOVATIONS
IN MATERIALS AND PROCESSES

AM&P asked companies involved with materials and processes to submit their innovations to a competition we call Companies to Watch in Materials Science and Engineering. The companies in this article have been selected as exceptional contributors to innovation in the materials industry. Congratulations to these outstanding innovators!

◆ATI Allvac

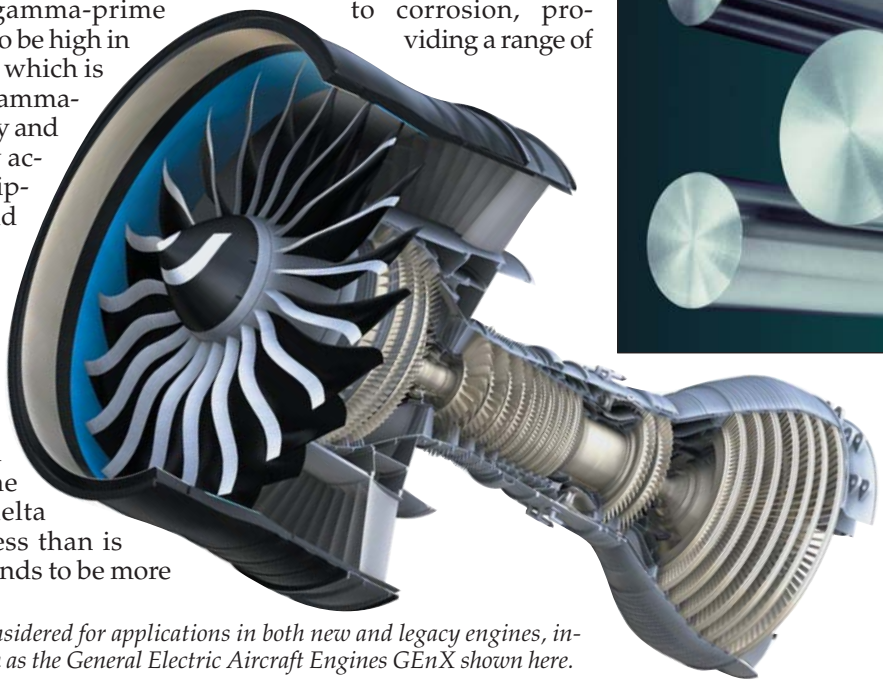
Allvac 718Plus is a new precipitation-hardened nickel-base superalloy that is capable of maintaining excellent strength and stress-rupture properties to 704°C (1300°F). The alloy is designed to have the temperature capability and thermal stability of Waspaloy, while retaining the processing characteristics of standard alloy 718.

In addition, 718Plus has a cost advantage over Waspaloy because of lower intrinsic raw material costs, as well as improved hot workability and weldability that leads to better material yields in finished parts. These characteristics make it ideal for both rotating and non-rotating components in next-generation turbine engines, or for replacing incumbent alloys such as Waspaloy and René 41 in legacy engines.

The primary strengthening phase is gamma-prime, with a volume fraction ranging from 19.7 to 23.2 %, depending on the quantity of delta phase. Studies of the gamma-prime phase in 718Plus show it to be high in niobium and aluminum, which is very different from the gamma-prime present in Waspaloy and René 41. In fact, this may account for its unique precipitation behavior and strengthening effects.

Alloy 718Plus also contains the delta phase, which is beneficial for conferring stress-rupture notch ductility and controlling microstructure during thermomechanical processing. However, the volume fraction of the delta phase is considerably less than is found in alloy 718, and tends to be more stable, with a much slower growth rate at elevated temperatures.

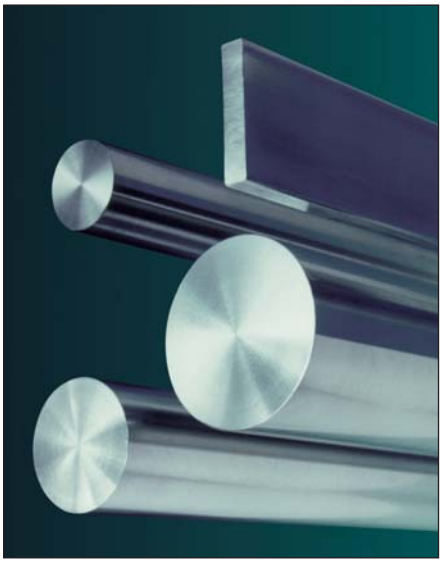
For more information: Howard Freese, ATI Allvac, 2020 Ashcraft Avenue, Monroe, NC 28110; tel: 704/289-4511; howard.freese@allvac.com; www.allvac.com.



Allvac 718Plus is being considered for applications in both new and legacy engines, including advanced engines such as the General Electric Aircraft Engines GEnX shown here.

◆Carpenter Technology Corporation

The AerMet ultrahigh-strength alloys, including AerMet 100 and the more recently introduced AerMet 310 and AerMet 340, have been developed to meet the demanding service requirements that designers of high-performance components require for aerospace structural applications. As a family, these alloys offer a unique combination of high strength, excellent ductility, high fracture toughness, and resistance to corrosion, providing a range of



Carpenter Technology's ultrahigh-strength Aermet alloys are available in a range of sizes and forms.

strength from 235 ksi to 275 ksi, and fracture toughness of 60 ksi $\sqrt{in}$. to 100 ksi $\sqrt{in}$.

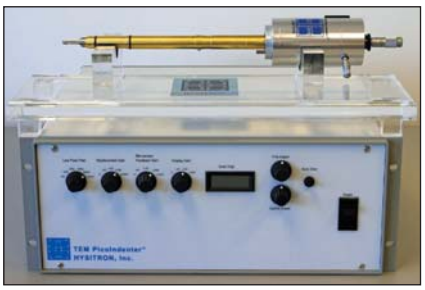
Another alloy, Custom 465 stainless, possesses a superior combination of strength, toughness, corrosion resistance, and strength-to-weight ratio compared with other high-strength stainless steels.

Carpenter Ferrium S53 is an ultrahigh-strength, corrosion-resistant stainless steel developed for U.S. Air Force aircraft landing gear. This alloy is produced and marketed by Carpenter, under license from QuesTek Innovations LLC.

For information: Lisa MacGregor, Carpenter Technology Corp., 101 West Bern Street, Reading, PA 19601; tel: 610/208-3479; e-mail: lmacgregor@cartech.com; www.cartech.com.

◆Hysitron Inc.

In the last year, Hysitron has released two in-situ nanoindentation tools, the TEM PicoIndenter and nanoECR. The TEM PicoIndenter is the first instrument to enable real-time, direct-observation (or in-situ) depth-sensing indentation inside a transmission electron microscope. Depth-sensing indentation (often called nanoindentation) involves continuously acquiring direct measures of the depth of penetration as a function of applied contact load while indenting a sample, usually with a sharp diamond indenter. With this coupling of high-resolution techniques, the load-depth (or force-displacement) curve can be time correlated to the TEM movie. For example, it could show the indentation-induced microstructure evolution of the sample.



Hysitron's nanoECR system is a multifunctional instrument capable of simultaneously measuring nanomechanical and electrical material properties from nanoscale contacts. NanoECR combines nanoindenter hardware with a conductive indenter probe and a voltage/current source to achieve a time-based correlation of force, displacement, voltage, and current. Both the TEM PicoIndenter and nanoECR are revolutionary instruments that provide the ability to obtain an in-situ correlation of the mechanical properties, material deformation behavior, and electrical characteristics that are important in areas ranging from fundamental material and device understanding to product performance and reliability.

For more information: Dr. Ryan Major, Sr. R&D Staff Scientist, Hysitron Inc., 10025 Valley View Road, Eden Prairie, MN 55344; tel: 952/835-6366; fax: 952/835-6166; rmajor@hysitron.com; www.hysitron.com.

◆Inductoheat Inc.

Inductoheat Inc. has developed the InductoScan, a high-performance induction heat-treating system for mid-to-high volume and/or multi-shift operations. Multiple scan-tower modules are available to accommodate a wide variety of parts.

User-friendly, the InductoScan is easily programmed through the PC operator interface providing maximum flexibility and easy use through simple parameter entry. Components and designs are field proven with more than 40 years of experience behind each machine. All equipment and tooling are backed by the world's largest designer and manufacturer of induction heating equipment.

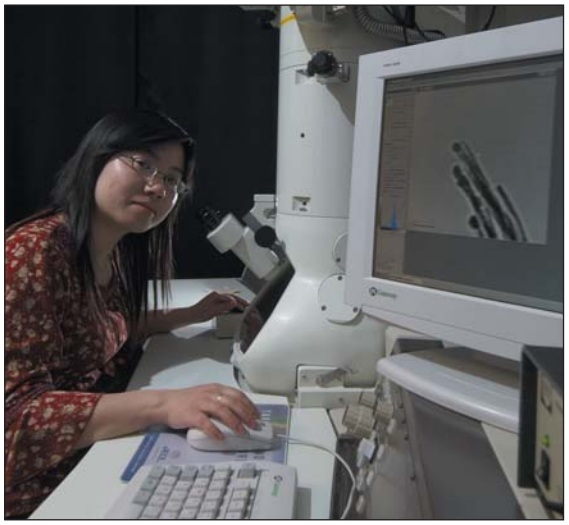
Mechanical modules provide various process solutions; scan, lift/rotate, pick & place, linear transfer, and rotary index. Flexible design also allows for a wide range of power supplies and controls to be changed or upgraded to meet future needs. Removable tank cover enables full access to all mechanical components for ease of maintenance or changeover.

InductoScan is a self-contained system on a common base to support standalone work cell requirements. User friendly PC/PLC based controls simplify setup, changeover, diagnostics, and process monitoring. It includes a quench recirculating system with plate and frame heat exchanger, and a water cooling recirculating system for inverter and coils.

For more information: Lauren Trimble, Inductoheat Inc., 10 Indel Ave., Rancocas, NJ 08073-0157; tel; 609/267-9000; www.inductoheat.com.

◆JEOL USA

JEOL electron microscopes deliver extremely high resolution for nanotechnology research and unprecedented quality for imaging fine surface details, analyzing biological and fabricated samples at the atomic level, and seeing microscopic details as they really are, magnified hundreds of thousands of times. Easy to use, flexible for a variety of



The JEOL transmission electron microscope helps researchers develop improved materials.

applications, and backed by award-winning support, JEOL electron microscopes play an influential role in the development of new products and materials, analysis for quality control and forensic investigations, and materials characterization.

For the crystallographer, metallurgist, or semiconductor research scientist, current high voltage/high resolution TEMs, utilizing 200 keV to 1 MeV, have permitted the routine imaging of atoms, allowing materials researchers to monitor and design materials with custom-tailored properties. With the addition of energy dispersive X-ray analysis (EDXA) or energy loss spectrometry (EELS), the TEM can also serve as an elemental analysis tool, capable of identifying the elements in areas less than 0.5µm in diameter. Cryo-EM and tomography help to develop 3D models of viruses, enabling researchers to mimic the self-assembling molecular structure to create new nanoparticles for materials science.

For more information: Pamela Mansfield, JEOL USA Inc., 11 Dearborn Road, Peabody, MA 01960; tel: 978/536-2309; www.jeolusa.com

◆Nanosteel Co.

The key to NanoSteel's new family of alloys, known as Super Hard Steel (SHS), is their ability to form very small property-enhancing, nanometer-sized grain structures. In doing so, SHS provides performance well above that of conventional steel and into the realm of tungsten-carbide products for wear and nickel-based superalloys for corrosion, without the associated high cost. Enhancing their ease of use, the patented SHS alloys are designed for conventional processing and application equipment.

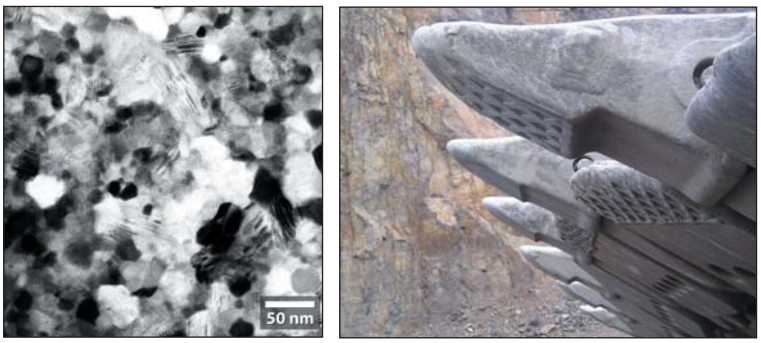
Now applied by thermal spray, welding, and laser cladding processes, NanoSteel's SHS atomized powder and wire products are extending the service life of mission-critical industrial components in the oil & gas, power generation, mining, and raw materials processing industries. After initially introducing SHS for thermal spray applications in 2002, Nanosteel extended the product line for service as a weld overlay in 2006.

The company is now developing new alloys to be the basis of nanostructured sheet steel and plate that will offer a unique combination of high performance with low cost from a highly recyclable and easy to use material. This combination has the potential to redefine steel for many different worldwide industries.

For more information: Greg Nixon, The NanoSteel Company, 67 Cedar Street, Suite 101, Providence, RI 02903; tel: 401/270-3549; fax: 401/270-9306; www.nanosteelco.com.

◆Newage Testing Instruments Inc.

Newage has developed a Brinell hardness testing system that combines several unique features for inline testing of hardened steel plate. First, the Brinell system allows the operator to select the system: ASTM E-103 for Brinell depth-of-indentation measurement, or E-10 for traditional optical Brinell measurement by an automatic scanning



Left, a TEM micrograph shows the nanometer-size grain structure of one of NanoSteel's SHS alloys. Right, the SHS hardfacing applied to the excavator bucket tooth in the foreground provides a sharp contrast in wear protection when compared to bucket teeth in the background which have not been hardfaced.

After extensive testing, NSL chemists determined that microwave-digestion would be a reliable test method that would save considerable time and cost for customers trying to comply with RoHS directives.

system. Second, the entire operational part of the system rests on a floating platform of air cylinders, enabling it to accommodate different plate thicknesses and distortions from heat treating.

Having two test methods provides the steel mill with the ability to test with standard E-10 method for customers with stricter requirements, or to use the more efficient depth-Brinell for other customers. The methods are equally accurate, but the E-10 method is more traditional.

The test cycle takes less than a minute. First, a trolley moves the tester into position next to a plate on the production line. The tester slightly lifts and clamps the edge of the plate, grinds the test location, then makes and measures an indentation via 3000 kg of test force. The waviness of the plate after heat treating necessitates the floating design, which allows so the tester to automatically accommodate different working heights.

For more information: Jeb Blair, Newage Testing Instruments Inc., 147 James Way, Southampton, PA 18966-3817; tel: 215/526-2200; jblair@newage-instruments.com; www.newageinstruments.com.

◆NSL Analytical Services

NSL recently solved a major testing problem faced by customers trying to comply with the RoHS Directive restricting the amount of high-mass-unit additives such as PBB and PBDE flame retardants in electrical equipment. The problem was the lack of a reliable, cost-effective way to test for flame retardants in polymers. An EPA method was originally adapted for this analysis, but it requires large samples and solvents that are expensive to dispose

of, and can take up to 24 hours to run. After extensive testing, NSL chemists determined that microwave-digestion would be a reliable test that would save considerable time and cost.

Basic steps in the process include FTIR analysis to determine polymer chemistry, and cryogenic grinding for efficient extraction. In the next step, a proprietary solvent is added for accurate quantification. Then the microwave digestion process is run three times to extract 99.999% of the additive. The material is then analyzed with GC/MS to determine the amount of additive.

This new method can serve to extract materials other than flame retardants, and future work will concentrate on proving applicability to other high-mass-unit additives in plastics, such as UV absorbers, stabilizers, plasticizers, and flow additives.

For more information: Greg CiCillo, NSL Analytical Services Inc., 4450 Cranwood Parkway, Cleveland, OH 44128; tel: 216/438-5200; 800/497-6752; www.nslanalytical.com.

◆Olympus NDT

Olympus NDT has been instrumental in the development of ultrasound phased array technology that offers considerable potential in the niche world of nondestructive testing. Phased array provides many advantages over conventional ultrasound and other NDT technologies. It has become user-friendly and realistically priced, with more products and applications, and lower prices predicted in the future. Phased arrays are remarkably versatile, with economical solutions to many industrial problems. Advantages of phased arrays include faster inspection speed, versatility in applications with easy setup changes, easy-to-read detailed cross-sectional scans of internal defects, small probe footprints for restricted test areas, and full data analysis and archiving.

The OmniScan is a portable phased array instrument that has become widely used in a variety of industries since it was introduced in 2003. It has a modular mainframe with replaceable technology modules (UT, PA, EC, ECA).

Olympus has applied this groundbreaking technology to real-world applications by developing a number of portable and automated inspection systems for a variety of maintenance and manufacturing applications. The portable modular OmniScan series of flaw detectors offers high-speed acquisition rates for both manual and automated inspections, the PipeWizard for automated inspection of pipeline girth welds, the TomoScan Focus LT acquisition unit, TomoView software, and a complete selection of phased array probes.

For more information: Meindert Andersen, Olympus NDT, 48 Woerd Avenue, Waltham, MA 02453; tel: 781/419-3900; www.olympusndt.com.

◆Powdermet Inc.

Powdermet has developed S-Comp, a family of structural syntactic metal composites with superior strength-to-weight ratios, better formability, and lower cost compared to honeycomb and integrally stiffened panel alternatives. S-Comp materials have exceptional energy-absorption capabilities and a structure closely approximating that of bone or wood.

S Comp's unique structure is a space-filling array of hollow reinforcements or microballoons, embedded in a metal matrix. These microballoons can be SLS glass, E-glass, mullite, alumina, SiC, or carbon, depending upon the metal matrix density and properties needed. S-Comp densities are typically 30 to 70% of the pure metal alloy. Modulus typically ranges from 25 to 50% of the parent metal alloy, while other mechanical properties can be 50 to 75% of the parent material.

S-Comp materials have an exceptional ability to absorb high impact energies, whether from large-body impact, ballistics, blade fragments, or collisions. Higher initial crushing strength make them ideal in situations where only high-energy threats are of concern, allowing smaller impacts to be deflected with no structural deformation while large threatening impacts are effectively absorbed. With more than five times the energy absorption per unit volume, and more than twice the energy absorption relative to weight than competitive metal aluminum foams, S-Comp metallic composites are ready for your impact and ballistic mitigation needs.

For more information: Brian Doud, Powdermet Inc., 24112 Rockwell Drive, Euclid, OH 44117; tel: 216/404-0053; bpdoud@powdermetinc.com; www.powdermetinc.com.

◆QuesTek Innovations LLC

Working with the United States Air Force, QuesTek Innovations LLC has computationally designed and developed a unique high-strength, high-toughness, corrosion-resistant steel to replace 300M in landing gear systems. 300M, the steel currently used in the vast majority of USAF landing gear components, requires cadmium plating for environmental protection. However, cadmium is a known carcinogen and represents hazards on install, overhaul, maintenance, and repair. The Air Force estimates $200M dollars is spent annually on landing

The A10 Warthog landing gear contains a piston made of the Questek Ferrium S53 alloy.

gear overhaul and repair, 80% of which is corrosion-related.

QuesTek has applied its Materials By Design methodology to computationally design a corrosion resistant steel named Ferrium S53, which meets Air Force requirements for landing gear. QuesTek has patented the alloy and has already licensed its first licensee for production and distribution. The design, scale-up, qualification, and licensing of S53 validates QuesTek's unique business model as a materials design firm with expertise in the development and licensing of intellectual property. AMS and MMPDS specifications for Ferrium S53 are anticipated in 2007, and the U.S. Air Force is now actively working on component qualification. Once implemented, Ferrium S53 will reduce corrosion condemnations, dramatically improve stress-corrosion-cracking resistance, and result in more robust and safe landing gear for the Air Force fleet.

For more information: Brian Tufts, Materials Design Engineer, QuesTek Innovations LLC, 1820 Ridge Ave., Evanston, IL 60201; tel: 847/425-8241; fax: 847/328-5855; btufts@questek.com.

◆Struers Inc.

The Struers TargetSystem is a significant advance in the microelectronics industry's approach to microsectioning and sample preparation for failure analysis. The system has reduced sample preparation times from about eight hours to just 35 minutes, and it provides excellent finished polish quality.

The system allows the user, through a fully automated process, to view both hidden and visible targets such as microvias and wire bonds. This is done through two setup stations, TargetZ and TargetX.

TargetZ is a video microscope for viewing and sighting specific distances to visible targets. With a powerful vision system of up to 680X magnification and its 15-inch TFT monitor, TargetZ makes it a simple task to map and align even minute targets.

TargetX is a console allowing for the positioning of the specimen within the customer's existing X-ray machine, and for sighting specific distances to hidden targets.

The Struers Target System is the first failure analysis tool that permits real-time alignment and measurement of both visible and hidden targets, such as microvias and BGAs.

TargetDoser is an automatic dosing station, providing preparation methods and process liquids to TargetMaster. It has seven pumps and ten pre-programmed methods, and accommodates 200 user-defined methods.

The TargetSystem also provides precision automated grinding and polishing to the pre-determined target, with an accuracy of +/-5 microns or better.

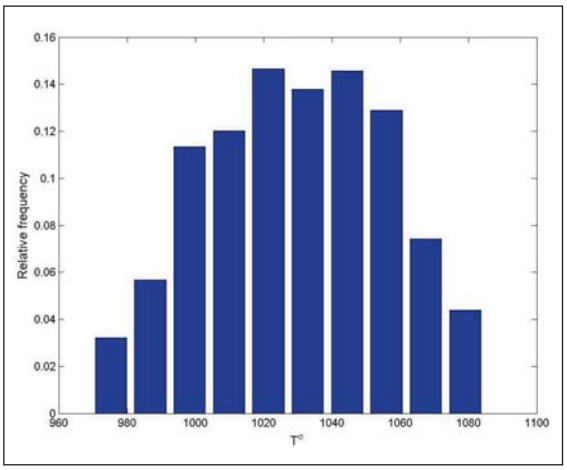
For more information: Struers Inc., 24766 Detroit Road, Westlake, OH 44145; tel: 440/871-0071; www.struers.com.

◆Thermo-Calc Software Inc.

Thermo-Calc is a leading developer of software and databases for calculations involving computational thermodynamics and diffusion-controlled simulations. It is a powerful software package for thermodynamic calculations for multicomponent systems relevant to iron, nickel, aluminum, titanium, and magnesium-base alloys, as well as other complex systems.

Thermo-Calc sold its first license to a commercial company in 1984. Since then, the Calphad methodology on which Thermo-Calc is based, the software and databases, have been continuously developed and are now widely used within industry, government research labs, and academia. Once seen as more of a research tool, Thermo-Calc now serves not only to design new alloys, but also to predict phase balances and precipitate formation based on specific chemistries as a way of improving quality control and anticipating problematic heats ahead of time.

Thermo-Calc Software has recently announced the release of TCFE5, a thermodynamic database for different kinds of steels and iron-base alloys for Thermo-Calc and DICTRA. This release follows a three-year collaborative program for stainless steels carried out within the framework of the Centre for Computational Thermodynamics; the CCT is a collaboration between the Royal Institute of Technology (Stockholm, Sweden), Kimab, and Swedish industry. Besides improving upon the accuracy of predictions compared with earlier versions of this database, TCFE5 also includes



Thermo-Calc can be used to calculate how the temperature at which sigma phase first appears varies within the normal range of composition for a particular alloy.

Innovations in materials and processes are the foundation for advances in every industry, especially aerospace, automotive, and electronics.

The CRISP system is shown being inspected shortly after its installation by one of the initiators of CRISP, Prof. Dr. Eckhard Quandt (center) who is now at the Christian Albrechts University in Kiel; Dr. Markus Dilger, Managing Director of the Nano Technology Systems Division at Carl Zeiss SMT (right); and Dr. Hartwig Bechte (left), Commercial Administrator at the Caesar Institute.

VisiTec has developed a large-chamber scanning electron microscope that is combined with a hydraulic tensile tester.

molar volume data for the phases, which allows for the prediction of volume fraction of phases, as well as density and thermal expansivity based on composition and temperature.

For more information: Paul Mason, President, Thermo-Calc Software Inc., 4160 Washington Road, Suite 230, McMurray, PA 15317; tel: 724/731 0074; fax: 724/731 0078; www.thermocalc.com.

◆VisiTec of America

VisiTec has developed a large-chamber scanning electron microscope that combines an LC-SEM with a MTS Hydraulic Tensile Tester. It includes a node control mechanism that creates a still observation node at any location on the specimen during fatigue cycling, allowing a point of interest to remain within view. The exceptional stability of this machine enables improved in-situ study of the fatigue-cracking phenomenon.

The tensile testing machine is mounted on a steel frame and is introduced inside the vacuum chamber. In this combined test, not only the force and break point of the material are determined, but also the crack is available to be viewed and studied thanks to the microscope.

In this way, the microscope is transformed into a complete testing device. The properties of the materials can be studied after fatigue testing, delivering complete testing results. This system increases the ability to record material structural changes that precede crack nucleation, and allows observation of the influences of microstructure on the early stages of crack propagation.

For more information: Adriana Romero, Director, VisiTec of America, 200 Prosperity Drive, Oak Ridge, TN 37923; tel: 895/228-1851; romero @visitec-em.de; www.visitec-em.de.

◆Carl Zeiss SMT

The Nano Technology Systems Division of Carl Zeiss SMT has developed a unique transmission electron microscope (TEM) for the imaging and analysis of materials with atomic resolution. The CRISP (Corrected Illumination Scanning TEM Probe) system utilizes a variety of uniquely combined electron-optical innovations. These include, above all, an imaging energy filter from the Zeiss 200kV Libra 200 instrument generation, supplemented with an electrostatic electron monochromator and an aberration-corrected illumination system. These technological innovations provide unparalleled insights into the innermost properties of materials.

A special CRISP application, in addition to the established projection imaging of the specimen structure, is the possibility of scanning the object with an atomic-sized electron probe.

It is also possible to scan an image with the specimen signal generated in the process of scanning via TEM. In doing so, the special corrector in the CRISP illumination system leads to an improvement of the spatial resolution down to atomic resolution.

In other words, it is possible to image atoms at a distance of less than one ten-millionth of a millimeter (= 1 Angstrom). Furthermore, the corrector permits the use of a beam current that is a factor of ten higher than standard systems, which significantly improves the reliability of chemical analyses and the acquisition time of the measurements.

For more information: Markus Wiederspahn, Germany; tel: +49 73 64 20 21 94; email: wiederspahn @smt.zeiss.com; www.zeiss.com. ⬣