Researchers building foundation for heat-tolerant electronics

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AFOSR awards $2.9 million grant to CWRU-led effort

Case Western Reserve University is leading an international investigation of a finicky alternative to silicon-based electronics and its use in high temperatures or under radiation that would render traditional components useless.

The Air Force Office of Scientific Research has awarded a $2.9 million grant to the engineers and scientists to systematically analyze what's called a Quasi-2Dimensional-Electron Gas (Q-2D-EG) forming at an oxide-heterointerface. The interface between a metal oxide film and a substrate, can be formed into a transistor.

The goal is to make it in such a way that it will operate at more than 200 degrees Celsius without external cooling.

These researchers and others investigators studying and developing technologies aimed at producing hardier electronics, materials and devices are kicking off their efforts at the Office of Scientific Research's weeklong Aerospace Materials for Extreme Environments Program Review, which begins Monday, Feb. 11.

Air and space, automotive, oil and gas drilling and nuclear industries can benefit from devices that can handle extreme environments.

Researchers have shown that they can form the electron gas – basically a two dimensional layer with large electrical conductivity – between two insulating oxides. This layer of conductivity can be manipulated, that is tuned, to make the conductivity stronger or weaker. And, using external electrical forces, scientists have changed the conductivity, essentially creating two electrical states equivalent to binary numbers to store memory. But none of these phenomena are well understood.

"This is temperamental stuff: only when you have a certain film on a certain substrate at a certain orientation and thickness, and prepared in a certain way does it work. The films we are talking about are only a few atomic layers thick" said Alp Sehirlioglu, an assistant research professor of materials science and engineering at Case Western Reserve, and leader of the investigation.

The electron-gas-producing interfaces can be designed as transistors and are applicable for developing next generation nano-scale, non-volatile memory devices, the researchers say. The investigators also propose to develop a new way to use the interfaces for applications such as memristors; another type of memory device dependent on the defects in the film.

But to do that, they have to understand a lot of basic information.

To begin with, the research team will identify how the electrical charge is formed at the heterointerface. They will mainly investigate interfaces between a lanthanum aluminum oxide film deposited on to a strontium titanate single crystal substrate. The investigators will study ways of processing the materials with controlled variation of defects, interfacial strains caused by different materials, and surface conditions,all as a function of temperature.

All the parameters contribute to the electrical behavior of the interface and are affected differently by temperature, the researchers say.

Their goal is to find the characteristics that, when combined, produce the best properties.

Sehirlioglu will investigate processing and compositional analysis of films and perform bulk structural analysis.

Also from Case Western Reserve, Walter Lambrecht, a physics professor, will model the electronic structure of point defects, and determine their quantitative contribution to the Q-2D-EG. Xuan Gao, an assistant professor of physics, will characterize the electrical properties of the interfaces as a function of temperature.

Marie-Helene Berger, at Ecole de Mines, Paris, will characterize interface nanostructures, point and line defects, and more.

Wei Lu, an associate professor of electrical engineering and computer science at the University of Michigan will build devices based on the findings.

Reviewers from the Air Force office said it is funding this team because it offers the right mix of specialties and capabilities to uncover the fundamentals needed to design new materials with properties specifically tailored to withstand extremes.

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