POPULAR SUMMARY FACT SHEET:
SCANNING NEAR-FIELD MICROWAVE MICROSCOPE

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WHAT IS IT?

Our invention is called a "Scanning Near-field Microwave Microscope." It can take very detailed, microscopic-level pictures of objects by using microwaves. Most people think of microwaves as something that cooks food, but that's only one use for them. Microwaves are actually an invisible form of light. And microwaves can do much more than bounce around in an oven. Like radio waves, microwaves can be broadcast over very large distances. In fact, cell phones work by receiving and broadcasting microwaves. The satellites in our sky also use microwaves to communicate with stations on the ground, and other satellites.

WHAT DOES IT DO?

The microscope can do two kinds of things. First, it can take pictures of an object with microscopic detail, and determine how its characteristics change at different points of the object. Second, it can take three-dimensional pictures of microwave fields. Microwave fields are produced by many electronic devices, including next-generation computer circuits.

To take pictures of an object, we first produce microwaves by using the electronic circuitry of the microscope. We then place the microscope's probe very close to the object that we wish to study. We send the microwaves through a tiny opening at the end of the probe. The object of interest reflects the microwaves in a way that depends on its properties (such as its electrical resistance and the bumpiness of its surface) at that particular point of the object. Some of these reflected microwaves enter the probe. These microwaves contain electric and magnetic fields. Inside the probe, these fields affect the electric fields and magnetic fields that already exist inside the microscope. In fact, they change the rate at which energy is exchanged between these electric and magnetic fields, and the rate at which microwave radiation leaks out of the probe. These changes are recorded at each position of the object. We move the probe back and forth across the sample, in a process we call "scanning." Through this scanning process, we can build up a picture of this objects and information on how its properties change at different points in the object. For certain objects, we can see

details of under 1 micrometer---very small indeed, since an average human hair has a thickness of 75 micrometers!

To measure microwave signals from electronic devices, we place the probe close to the electronic circuit once again. We simply measure the microwave fields emanating from the device. These fields alter the properties of the electric and magnetic fields inside the microscope similar to the way described above. With this process, we can build up a three-dimensional picture of the electric and magnetic fields in the microwave signal produced by the circuit.

WHAT UNIQUE CAPABILITIES DOES IT HAVE?
Our device can take pictures of materials and study their properties at precisely the temperature and frequency we want. It can take three-dimensional pictures of an electronic device's microwave fields at whatever frequency we would like the device to operate. It can take pictures of the device's microwave fields while the device is in operation. These images can be compared to computer predictions of the field patterns which are routinely generated in the design of microwave devices. It can image at such fine details in order to connect the microscopic structure of materials to their electromagnetic properties.

WHO INVENTED IT?
Professors Steven M. Anlage, and Frederick C. Wellstood, along with their graduate students C. P. Vlahacos and David Steinhauer. Additional work has been done by Sudeep Dutta, Johan Feenstra, and Ashfaq Thanawalla.

WHO SUPPORTS THE RESEARCH?
The National Science Foundation (NSF) through the Electrical, Communications and Cyber Systems (ECCS) Division, and the NSF Materials Research Science and Engineering Center (MRSEC), and the Maryland Center for Nanophysics and Advanced Materials.

WHO OWNS THE PATENTS?
The University of Maryland has received several US patents for the invention. The University can negotiate a licensing agreement with anyone interested in developing a commercial version of this microscope.

For Further Information:
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