other prion-type proteins … but we don't know of them."

Lindquist champions the view that prionlike proteins are common in mammals, including humans, but that they might not normally cause disease. "It depends entirely on the kinds of proteins they interact with," she says. It's also possible that some prions are intrinsically more prone to toxicity than others. Despite their potential for harm, Lindquist adds, prions likely extend benefits, too. "It's a wonderful means for very stably transmitting information," she says, referring to the prion's ability to convert proteins in cells around it to the same form. "Once you set up certain states, having structures that tend to be self-perpetuating makes a lot of sense." The logic is finding support in at least one provocative new line of inquiry.

Tantalizing evidence for benign prionlike proteins—they don't match up to true prions—is coming from Nobelist Eric Kandel's lab at Columbia University in New York City. Kandel and lab member Kausik Si are studying a common protein in neurons called CPEB, a section of which resembles parts of prions in yeast. Preliminary evidence suggests that the protein can self-perpetuate in mammalian brains, the pair reported at a National Academy of Sciences meeting in March. Although cautioning that the evidence is extremely preliminary, they speculate that it might play a role in storing information—in other words, in memory.

Lindquist argues that further study of prions—or self-perpetuating proteins, as she likes to call them—will help explain what makes at least one of them harmful. Hazardous and not, she and others believe, many more prions are out there, waiting to be revealed.

–JENNIFER COUZIN

SENSING

Brainstorming Their Way to An Imaging Revolution

In June, a handpicked team of researchers locked themselves away in an R&D hothouse to produce a new detector of elusive terahertz waves. Their prototype is already being tested

OXFORD, U.K.—Terahertz waves penetrate fog, peer through paper and clothes, and look into human tissue, but their useful properties are terra incognita to most because of the huge cost of existing sensors. Last week, however, a team of scientists from across Europe began testing an imaging chip that could open up this long-neglected part of the electromagnetic spectrum to new applications, from medical imaging to satellite observations of Earth. The device itself is intriguing enough, but equally novel is how it's being developed.

The process began in November 1999, when a pair of physical scientists embarked on a breakneck effort to fabricate a new material that can completely block out terahertz waves. This radiation, in the nether region between infrared and radio waves, is hard to detect, but a so-called photonic bandgap material impervious to terahertz waves could revolutionize imaging devices, greatly improving their ability to peer through materials opaque to light of many other wavelengths. Chris Mann of Rutherford Appleton Laboratory (RAL) near Oxford, U.K., and Ramón Gonzalo of the Public University of Navarra in Spain cloistered themselves away in RAL for a month to come up with the goods.

The duo succeeded, producing a prototype terahertz-blocking silicon material. Musing over their accomplishment in a Pamplona bar in May 2000, Mann, Gonzalo, and Peter de Maagt of the European Space Agency (ESA) agreed that this kind of forced, intense teamwork—a mini–Manhattan Project approach—might be just the ticket to take the next, more difficult, step in terahertz imaging. They hatched a plan that night to assemble a crack R&D team to design a terahertz imager that could be deployed in space and elsewhere.

Hear them roar. The Star Tiger team, in a rare moment of relaxation with U.K. science minister David Sainsbury, seated third from left.

CREDIT: CCLRC

Two years later, the Star Tiger project, funded by ESA, is yielding its first fruits. A team of 11 researchers from across Europe, under the leadership of de Maagt, Mann, and RAL colleague Geoff McBride, last week began putting a prototype terahertz imager through its paces at an RAL lab. The scientists still face big technical hurdles if they are to reach their goal: production of a much more sophisticated chip by the end of the project in October. But they are zealous converts to the agency's novel multidisciplinary team approach. "If you want to find something innovative, it's the best way," says Luisa Deias, an electronics engineer from Italy and the team's sole female member. "This isn't work," adds British materials scientist James O'Neill. "We're just having fun."

The seed that germinated in the Spanish bar 2 years ago fell on fertile ground at ESA. Back at the agency's technology research center in Noordwijk, the Netherlands, de Maagt mentioned the idea to his superiors. It quickly moved up the hierarchy, and in April 2001, ESA launched a feasibility study into building a terahertz imaging chip. Six months later, Mann and de Maagt got the go-ahead for a $650,000 project.

All objects emit terahertz waves, just as they emit infrared radiation, but terahertz waves are much harder to detect. Existing imaging devices were originally designed by the military to help land aircraft in fog, but they are complex, bulky, and expensive. Chip-sized detectors could be mass-produced and thus could open up new markets. A terahertz imager at an airport, for example, would be able to see through passengers' clothes and reveal hidden weapons, which emit more terahertz waves than the human body does. Every airliner could have a detector in its nose cone, allowing the pilot, on a foggy night, to see the runway. And—the reason ESA got involved in the project—satellites could use them to look down at Earth through cloud cover or up at the stars at this little-studied wavelength.

To make a tiny chip-sized detector practical, you have to ensure that as many of the weak incoming waves as possible make it into the detector rather than leaking into the surroundings or into the chip material itself. The semiconductors that chip substrates are normally made of are a big impediment:

They soak up terahertz waves like a sponge. That's where photonic bandgap materials come in (see sidebar). This substrate reflects rather than absorbs the waves, and it can be shaped like a cone to funnel incoming waves to a chip's detector elements. It's like making a telescope mirror out of polished glass rather than black felt. "Photonic bandgap materials have the potential to revolutionize terahertz technology," says Mann.

First, however, the Star Tiger organizers had to recruit a team. They advertised the project earlier this year, and in late April, 16 candidates—ranging from newly minted graduates to seasoned postdocs—gathered in a country house in Oxfordshire, U.K., for an intense weekend of personality tests, technical presentations, group discussions, and interviews. "Everyone was really stressed," says Dutch team member Frank van de Water, a waveguide designer. The lucky 11 were informed of their selection a few days later. But when they arrived at RAL on 5 June, they found an empty room with computers and other equipment still in boxes. "Setting up the room was a team-building exercise," says McBride. The team building continued when Mann whisked the whole group off to Cornwall—his home territory—for 2 days of brainstorming, with occasional breaks for surfing and other fun.

Several weeks into the project, in late June, spirits remained high. "The magic thing about Star Tiger is putting everyone in one room," says British space scientist Alec McCalden. The result, team members say, is an intellectual ferment rarely found in an academic setting. "Here everyone has very different points of view. It opens your mind," says Spain's Iñigo Ederra, an antenna engineer. Adds his compatriot and fellow antenna designer Jorge Teniente Vallinas, "Every day there is a new idea from someone." Star Tiger's leaders ensure that the scientists are not distracted by administration. "Without the burden of bureaucracy, we will be able to do in 4 months what would normally take 1 to 2 years," says Deias.

Spot the knife? Millimeter waves, close to terahertz, show their ability to see through clothes and paper.

CREDIT: QINETIQ

Terahertz on a Chip

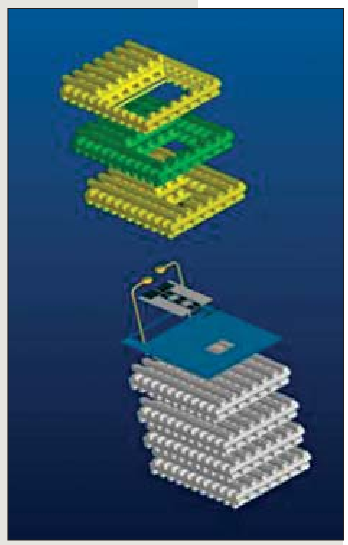
The Star Tiger team refers affectionately to its photonic bandgap material as a "woodpile." In the bottom layer, silicon "logs" are lined up in one direction, while the next layer has them perpendicular to the first, and so on. This arrangement creates a macroscopic version of a crystal lattice: a structure with arrays of holes like the serried ranks of atoms in a crystal. And just as a semiconductor's crystalline structure can forbid the movement of electrons with particular energies—an energy bandgap—a silicon woodpile blocks certain wavelengths of radiation.

The size and spacing of the holes are finely tuned so that when radiation of a particular wavelength range impinges on the material, the waves are refracted and reflected by all the surfaces around the holes to the point where they shift out of phase and cancel each other out. The waves can't propagate through it, so the material behaves like a three-dimensional mirror: Shine light from any direction, and it gets bounced back out. To make Star Tiger's terahertz "mirror," a dicing saw carves grooves out of both sides of a thin silicon wafer, forming a two-layer woodpile. Stacking produces thicker piles.

Because the technology doesn't exist to detect terahertz waves directly, the detector circuits of Star Tiger's chip generate terahertz waves of a known frequency and mix them with incoming terahertz waves funneled down a feedhorn cut in a top layer of woodpile. The two sets of waves cancel each other out in some places and reinforce in others to produce a wave with a much lower frequency, equal to the difference between the two original frequencies. This manageable radio-frequency signal is filtered, amplified, and detected by other chip elements, then sent to a computer for analysis.

Building a working detector is within reach, says Dutch waveguide designer Frank van de Water. "This goal is definitely achievable," he says. "We have to believe in it."

–D.C.



The layered look. Detector circuits on a bandgap material. More "woodpiles" form a feedhorn on top.

Preparing the prototype this month has been the group's first real test. As a demonstration of their ideas, they have constructed a single-pixel detector made up of a cone-shaped feedhorn channeling radiation to oscillators, mixers, amplifiers, and detectors embedded on a chip below. The aim is to produce a terahertz image of a human hand in 30 seconds or less. To do this with a single pixel, moving mirrors focus radiation from different parts of the hand onto the pixel in quick succession.

Ultimately the team wants to build as many as 32 pixels onto a chip, either in a square array or in a row that can be scanned across the target. They hope to do away with the moving mirrors by electronically steering the array so that it is sensitive to waves coming from different directions.

The team has a good shot at succeeding, says Don Arnone, chief executive of TeraView, a Cambridge, U.K., firm set up last year to make terahertz medical imaging systems. Such devices illuminate the body with a source of terahertz waves and analyze reflected signals for signs of cancer, as the waves are better than x-rays at contrasting cancerous and healthy areas in the skin, breast, or other soft tissues. A system like Star Tiger's—which picks up only naturally emitted waves—would be "commercially very attractive" and have many applications, particularly in airport security, Arnone says. The key challenge is creating an imager that can scan a whole person fast enough.

The October finish line for Star Tiger might seem a distant target for the researchers now working full out. "Enthusiasm will flag. People get tired," says McBride. "But they look after each other. They will look after the ones that fall." And team members are convinced that the experience will benefit them down the road. According to German materials scientist Alfred Zinn, "it will pay off in the future when we go off to our universities and one day can call one another up and say, 'I've got this crazy idea, will it work?' The trust is already there."

–DANIEL CLERY