



Welcome, Daniel! ACS ACS Publications C&EN CAS



**C&EN**  
CHEMICAL & ENGINEERING NEWS

Serving The Chemical, Life Sciences & Laboratory Worlds



About Subscribe Advertise Contact Join ACS ?

**SEARCH**

Advanced Search

Home
Magazine ▾
News ▾
Departments ▾
Collections ▾
Blogs ▾
Multimedia ▾
Jobs ▾

Home > Volume 91 Issue 5 > Taking NMR And MRI To The Nanoscale

**Volume 91 Issue 5 | p. 4 | News of The Week**  
Issue Date: February 4, 2013

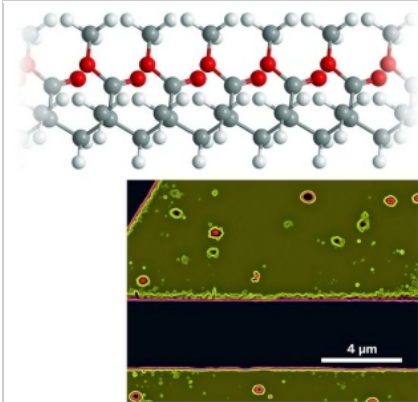
## Taking NMR And MRI To The Nanoscale

Spectroscopy: New detector fills gaps in existing analysis techniques

By [Jyllian Kemsley](#)

Department: [Science & Technology](#)  
 News Channels: [Analytical SCENE](#), [Biological SCENE](#)  
 Keywords: [NMR](#), [MRI](#), [fluorescence](#), [diamond](#), [nitrogen-vacancy](#)

[+][Enlarge](#)



In the new NMR detector, shown here in a fluorescence microscope image, the intensity of fluorescence from nitrogen-vacancy centers (red and black circles) in diamond (yellow-green) depends on the nuclear spin polarization of the sample, in this case poly(methyl methacrylate) (structure). The black stripe is a microfabricated wire.  
Credit: IBM Research

**Understanding the inner** workings of biology or materials science requires both structural and chemical knowledge, but current analysis techniques have limits: They may require large sample sizes, crystallization, or low temperatures, or they show structural features without chemical information—or the reverse. A new approach to nuclear magnetic resonance (NMR) spectroscopy provides a path to both chemical and three-dimensional structural information of nanoscale-sized samples at ambient temperature.

In traditional NMR spectroscopy, a sample is placed in a magnetic field. The spins of nuclei with odd numbers of protons and neutrons—commonly hydrogen and carbon-13—line up with or against the magnetic field. Slightly more of the nuclei line up with the field, leading to nuclear spin polarization. The polarization is measured by exciting the nuclei with a radio-frequency pulse and detecting the energy they emit. The medical technique magnetic resonance imaging (MRI) works similarly.

The conventional NMR or MRI detector is an electrical coil, and that's been a limiting factor in reducing sample scales. "It just isn't sensitive enough to go below the micrometer scale," says [Daniel Rugar](#), manager of nanoscale studies at [IBM's Almaden Research Center](#) in San Jose, Calif. Rugar led one of two separate groups that reported similar nanoscale NMR techniques in *Science* (DOI: [10.1126/science.1231540](#) and [10.1126/science.1231675](#)).

To downscale NMR, both groups used a detector made of diamond with a site defect called a single nitrogen-vacancy (NV) center, in which a nitrogen atom and a lattice hole replace two adjacent carbon atoms. Prior work had determined that NV centers are sensitive to the internal magnetic fields of the diamond. The new research demonstrates that the fluorescence of such centers can be used to detect magnetic fields emanating from just outside the diamond. Both groups were able to use NV centers to detect nuclear polarization of hydrogens in poly(methyl methacrylate) with a sample volume lower limit of about (5 nm)<sup>3</sup>. Further development is necessary to extract structural information.

Unlike conventional NMR or MRI, the NV technique does not need an external magnetic field. Because of the relatively small number of atoms in nanosized samples, the nuclear spins are not in perfect equilibrium and so are naturally polarized, says Friedemann Reinhard, a researcher at the [University of Stuttgart's Third Physics Institute](#), in Germany, who led the second nanoscale NMR group. The magnetic state of NV centers changes in response to the nuclear polarization of the sample.

Although researchers had predicted that NV centers could be used to detect NMR signals from small volumes, "it is very exciting to see work in both these papers that clearly shows it can really be done," says [Lyndon Emsley](#), scientific director of the [European Centre for High Field NMR](#), in Lyon, France.

Both groups "describe beautiful work," says [Alexander Pines](#), a chemistry professor at the [University of California, Berkeley](#). Pines foresees "exciting applications in systems from materials to biology."

On the biology side, the technique could determine structures of proteins that cannot be crystallized or could identify different

**MOST POPULAR**

Viewed Commented Shared

[Caffeine Jitters](#)

[Assessing The Safety Of Lithium-Ion Batteries](#)

[Carbon Nanotubes Help Grow Beating Heart Tissue](#)

[Oil Dispersants Used During Gulf Spill Degrade Slowly In Cold Water](#)

[EU Carbon Emissions Trading Scheme In Freefall](#)  
\*Most Viewed in the last 7 days

0

Email  Print 

0

conformations of individual proteins, Rugar elaborates. It also opens the door to performing NMR of biomolecules in living cells.

For materials science, transistors will soon have dimensions of tens of nanometers or smaller, Reinhard notes. At that point, the identity or position of single atoms may be key to performance. Nanoscale NMR will enable determination of subsurface chemical composition, he says.

Chemical & Engineering News  
ISSN 0009-2347  
Copyright © 2013 American Chemical Society

## Comments

**Josh Kurutz** (02/01/2013 at 8:45 AM)

It's always great to see fundamental advances being made in NMR. To see this work coming from an INDUSTRIAL research lab gives one hope. Kudos to the IBM team!

» [Reply](#)

## Leave A Comment

Thank you for your comment. Your initial comment will be reviewed prior to appearing on the site. Please check back in a few minutes to see your post.

Name

Email Address(Required to comment)

**SUBMIT**

### Chemical & Engineering News

[Home](#)  
[Magazine](#)  
[News](#)  
[Departments](#)  
[Collections](#)  
[Blogs](#)  
[Multimedia](#)  
[Jobs](#)

[Subscribe](#)  
[Advertise](#)  
[Contact](#)  
[Join ACS](#)  
[About](#)



[Help](#)  
[Sitemap](#)

Search

**SEARCH**

[Advanced Search](#)

### American Chemical Society

[ACS.org](#)  
[ACS Publications](#)  
[CAS](#)

Copyright ©2013 American Chemical Society