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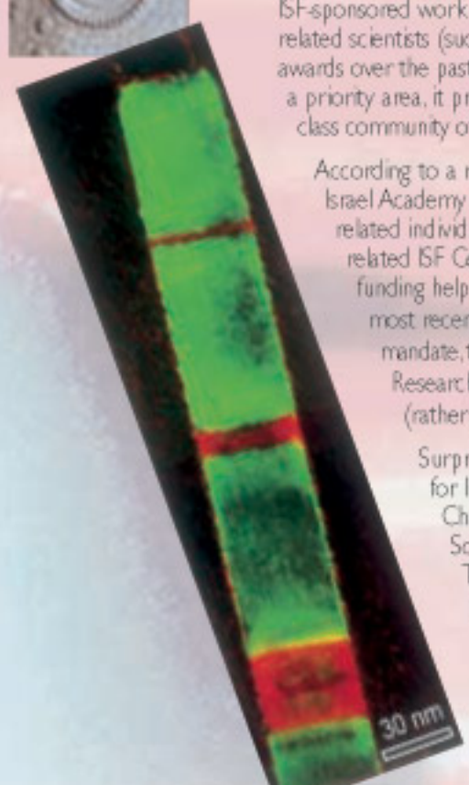
Nanotechnology: Israel Moving Small Fast



Nanoscience and nanotechnology (NST) is all about ultrasmall devices – a nanometer is just one-millionth the diameter of a human hair – with potentially ultra-big payoffs. That is why the U.S. Government's National Nanotechnology Initiative pumped $270 million into the area in 2000, and $500 million in 2002. Other foreign nanotechnology investments soared from $316 million in 1997 to $835 million in 2001. How is Israeli academia doing in this area? Surprisingly well, albeit on a much smaller scale.

Israeli scientists were quick to recognize the importance and potential of nanoscience and technology (NST). For example, the scanning tunneling microscope, STM, a basic NST tool, was invented only in 1982, leading to a Nobel Prize in 1986. But by 1989, with the help of the Israel Science Foundation (ISF), Prof. E. Gileadi already had one! By the time he had his first results, two years later, Profs. Y. Manassen and D. Mandler already had ISF-funded STM and electrochemical microscope research grants (respectively); and Prof. G. Haase had his first STM-related ISF grant by 1994. Similarly, Prof. I. Willner's and A. Shanzer's pioneering ISF-sponsored work on biosensors and molecular switches also dates back over a decade. In fact, Willner and other early NST-related scientists (such as Profs. Uri Banin and Ron Tenne) have received multiple ISF-related research project and/or equipment awards over the past decade. That is, although the ISF is a completely "open" grants competition, which never identified NST as a priority area, it provided the crucial framework and support which enabled Israeli researchers to "self-assemble" a world-class community of scientists doing basic research in this area.

According to a recent study of ISF nanotechnology projects, conducted by Dr. I. M. Asher, a science policy advisor at the Israel Academy of Sciences and Humanities, the ISF has, over the last five years alone (1997-2001), funded 30 clearly NST-related individual research projects at a total cost of about $3 million. A roughly equivalent amount was spent on NST-related ISF Centers of Excellence; and over $2 million, on major NST-related equipment systems. This $8-9 million of ISF funding helped build and maintain a growing, and constantly evolving, cadre of highly competitive NST researchers. The most recent five years has seen considerably more sophisticated and device-relevant research. However, given the ISF mandate, they still represent comparatively basic advances of comparatively wide and long-term impact (see accompanying Research Notes article). All 30 projects represent established excellence, as determined by external peer review (rather than emerging new startups).

Surprisingly, over half of the ISF's new NST grantees for 1997-2001 were found to be located in Chemistry departments; Materials Science came in a distant second. That is, Israel, quite appropriately, seems to be using its world-class

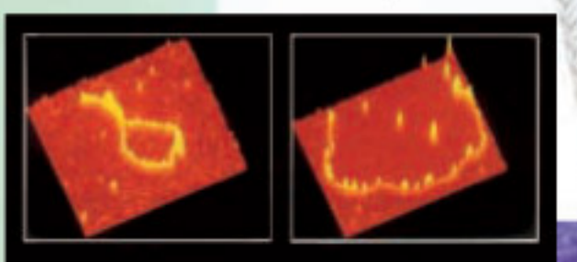
expertise in Chemistry to carve out an early, internationally competitive niche for itself in this area. The dearth of ISF NST grantees in engineering, while noteworthy, probably just reflects their access to more applied sources of funding, such as Israel's Ministry of Science (MOS), Ministry of Industry and Trade (MIT), Ministry of Defense (MOD) and high-tech industry. In any case, ISF NST reports do not display the neat electromicrographs of miniscule etched gears or lines of atoms spelling out "IBM" that grace Western NST publications. In fact, about one-third of all ISF NST projects involve the "wet" chemical self-assembly of simple nanostructures, nanowires and networks. Others involve nanoparticles and carbon nanotubes. However, the sudden appearance in 2001 of five ISF projects in NST-related research tools and materials, suggests that researchers in allied fields are *now* beginning to think of how their work can affect, and broaden, Israeli NST.

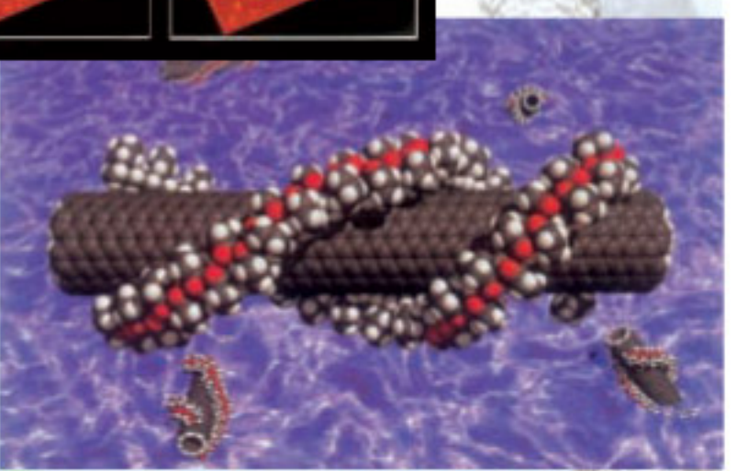
Most new ISF NST grantees in 1997-2001 were from the technology-intensive Technion and Weizmann Institute; however Israel's largest universities, Tel Aviv University and the Hebrew University, have already announced ambitious plans for major new NST centers and initiatives. Building on their previous success, the Technion has also announced plans for a new biology-oriented NST center. However, the "lag time" for these new efforts to come on-line is somewhat difficult to gauge. Meanwhile, there are hints of saturation, over the last five years, in the number of all new ISF-funded NST projects and currently active chemistry-related NST projects. That is, most established NST-oriented chemists wanting such grants may already have them, and much new short-term growth may come from comparatively "easy" (and then less easy) transitions to NST by established researchers in allied fields. The real test will be Israel's ability to train a new generation of NST researchers "from scratch," but there too some lag-time may be expected.

The first project funded by Israel's new FIRST (Focal Initiatives in Research in S&T) Program, established to proactively select and fund important new fields, was in NST. It involved the world famous breakthrough of E. Braun, U. Sivan and Y. Eichen, who gold-plated DNA molecules to create nanowires. Their success instantly made several decades of precise DNA-manipulating chemistry and technology potentially relevant to NST. FIRST subsequently chose NST as one of its three areas of focus, funding nine projects at a total cost of about $1.3 million during 1997-2002. These were comparatively balanced by field (Physics slightly outdid Chemistry) and institution (four received two grants each). Many FIRST grantees later received conventional ISF grants – supporting FIRST's role as a "quick start" mechanism for new science.

To be fully useful, this analysis of ISF NST grantees needs to be combined with similar analyses of other major sources of Israeli NST funding (MOS, MIT, MOD, industry), and a comparison with the national norms of other developed Western countries. Israel's current de facto policy of maintaining a broad spectrum of low-level research with concentrations of resources in selected subfields of demonstrable excellence should also be re-examined in the NST context. Both strategic components will require considerably more funding. Finally, the post-academic step of converting Israel's laboratory successes into useful products will require a totally different level of R&D and resources. In particular, the current economic crisis threatens to dismember or drain one of the most potentially vibrant sectors of Israel's future economy, unless substantial outside funds can be obtained.

These and other related issues, crucial to Israel's nanotechnological future, are *now* being investigated by a special international committee appointed by TELEM, Israel's Forum for National R&D Infrastructure, which includes the Israel Academy, the Israel Council for Higher Education and the major ministries involved in funding Israeli S&T at the national level (see The FORUM, Autumn 1998). TELEM has asked Dan Maydan, the internationally respected founder of Applied Materials, Inc., the world's largest supplier of semiconductor manufacturing systems, to chair this exceptionally high-level committee. The Maydan family has long been known for its enthusiastic encouragement of Israeli science and technology, including the recent donation of the 12-foot statue of Albert Einstein that has become an Israel Academy landmark (The FORUM, Spring 2000). Meetings have already been held in Israel and in the U.S., and more are planned.





Israeli nanotechnology has, indeed, become of age and is now a center of attention at the very highest level of the Israeli academic-government-industry enterprise.

Note: Other FORUM Research Notes articles related to Israeli NST were published in: Spring 1997/page 6, Spring 2000/page 2, Spring 2001/page 3.