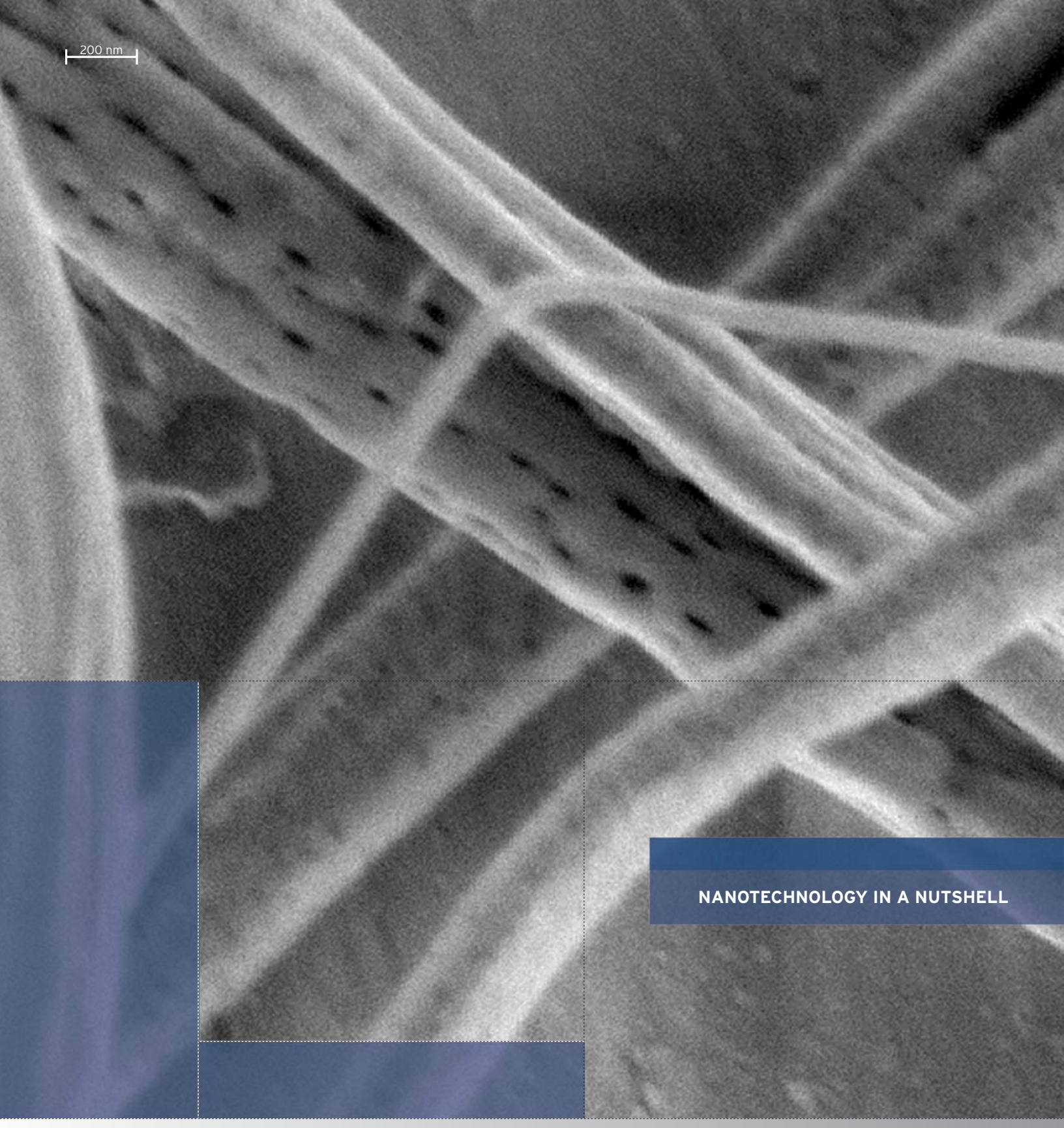

NANOTECHNOLOGY IN A NUTSHELL

ZYVEX WHITE PAPER

Nanotechnology, called "the next industrial revolution" by some and "over-hyped" by others, sounds complex. But the basics are pretty easy. This paper explains what it is, and hints at how it will change our lives.

The shortest science lesson you'll ever get

The world around us is made of atoms. We encounter them as pure elements like nickel, copper, gold, and aluminum; in precise combinations with other atoms forming molecules such as carbon dioxide (CO_2) and water (H_2O); or in complex mixtures such as sand (silicon and oxygen), steel (iron and a little carbon), or air (nitrogen, oxygen, and trace gases). How the atoms are arranged is absolutely crucial. A computer chip is, in essence, purified and processed beach sand. The complex molecular machinery of our body is made from the same atoms found in seawater.

A short history of technology

Technology lets us arrange atoms into tools that help us control our environment. Our control over the arrangement of atoms has grown since we first made wood clubs and clay pots. Progress in manufacturing is a story of increasing precision and control over the arrangement of atoms.

We now stand at the threshold of the nanotechnology age — in which we can, as the renowned physicist and Nobel Laureate Richard Feynman said, "arrange the atoms one by one." The predicted hundred-fold improvement in system performance will profoundly change national defense, medicine, computers, manufacturing, agriculture, and our environment stewardship.

Nature shows the way

Nature has been refining nanotechnology since life began. Consider the acorn, which can be viewed as a complex machine to produce more acorns. In the initial cell from whence the tree grows, a program is coded into the DNA, and a host of molecular machines exists to carry out that program. The DNA instructs those molecular machines — enzymes, proteins, ribosomes and others — to rearrange the atoms in dirt, water, and air into more cells. Powered by solar energy captured by the leaves, this program then instructs the cells to organize into a tree. The wood produced is actually a highly structured nanocomposite material more complex than anything we can build in the most advanced scientific laboratory in the world today. And yet, because of the power of this molecular scale manufacturing plant and its DNA programming, the tree builds wood at little cost, and without polluting our environment. From the acorn's point of view, the entire tree is just an acorn factory. From our view-point, the tree is an elegant and remarkably flexible manufacturing system.

Our nanotech future

Scientists don't yet fully understand all the complex processes going on inside a living cell. Oak tree DNA is not easily reprogrammed to make a different kind of tree, let alone to make computer chips or new materials. Yet as engineers, we are inspired by the tree's molecular scale machines to develop our own molecular scale machines, using both existing and new principles, to rearrange atoms into more valuable forms. Using electronic computers rather than DNA, we can instruct those machines to build a variety of products limited only by our imaginations and the laws of nature. We can start and stop these machines at will, and reprogram them to build advanced materials, computers, and someday, even molecular medical devices able to repair aging or injured cells. Today's technology merely lets us move and touch atoms. Tomorrow's technology will actually let us arrange those atoms in most ways compatible with the laws of physics.

Nanotechnology will profoundly change our world.

For further information, or to receive our other white papers, please contact:

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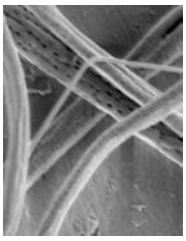

Cover photo: Image of carbon nanotube polymer composite fibers which were produced by electro spinning.

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