Report
HIGHLIGHTS

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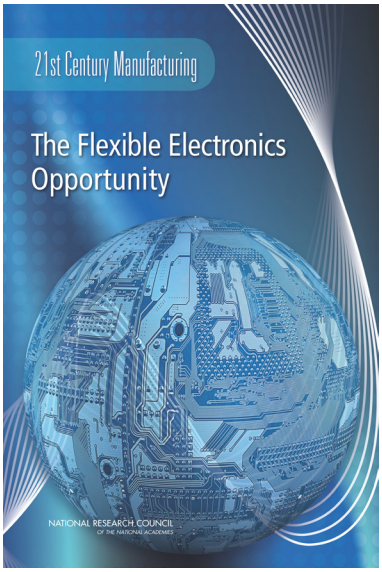
THE FLEXIBLE ELECTRONICS OPPORTUNITY



Flexible electronics use circuits that can bend and stretch, enabling versatility in applications and the prospect of low-cost manufacturing processes. Flexible circuits could enable advances in areas ranging from medical care to consumer electronics to alternative energy. The field has the potential to address national needs in national security, energy, and sustainable growth, and it offers an opportunity to establish another new high-technology industry that would be a major source of domestic manufacturing income and jobs.

Efforts to develop a flexible electronics industry in the U.S. face many challenges, however, including strong competition from abroad. In response to a congressional request, the National Research Council appointed a study committee to assess ways to advance the potential of this industry. The committee's report, The Flexible Electronics Opportunity, offers recommendations to develop a robust flexible electronics industry in the United States.

Collaboration among U.S. industry, universities, and government offers the best prospect for achieving the investment and the acceleration of technology development needed to develop a vibrant flexible electronics industry, the report concludes. To spur this collaboration, the U.S. should take steps such as establishing a network of user facilities dedicated to flexible electronics and using consortia to bring together industry, universities, and government as a way to foster precompetitive applied research. In addition, the nation should increase its funding of basic research related to flexible electronics.

A RENEWED FOCUS ON MANUFACTURING

At both the federal and state levels, a significant aspect of the policy response to the recent recession has been initiatives to bolster the U.S. manufacturing sector to reverse its long-term decline, foster onshore manufacturing operations, create new domestic jobs, and exploit the U.S. science and research base. In 2011, the federal government established the Advanced Manufacturing Partnership to coordinate investments in manufacturing by governments, universities, and industry. In 2012, the government announced that it would create 15 manufacturing research institutes around the country to strengthen U.S. manufacturing infrastructure.

Despite the erosion of many industries, the United States may be able once again to position itself to compete internationally in manufacturing. The United States has the world's foremost system of research universities, which have a long tradition of working with industry to promote innovation in manufacturing. A 2012 survey by the Massachusetts Institute of Technology found that a number of factors were combining to favor "re-shoring" of manufacturing in the United States, citing U.S. advances in automation and manufacturing techniques, declines in domestic natural gas prices, and the advent of additive manufacturing and nanotechnology.

THE POTENTIAL OF FLEXIBLE ELECTRONICS

Flexible electronics are electronic devices that can be bent, folded, or stretched without losing functionality, unlike conventional electronics, which are typically built on thick, inflexible substrates.

Flexible electronics have a range of potential applications, including:

- Bendable and reliable displays for smartphones that can be rolled up or folded
- Stretchable electronic "skin" and other devices that can monitor health
- Smart fabrics that can modify their characteristics in response to external stimuli
- Flexible photovoltaic and lighting systems that can be applied to curved or irregular surfaces
- Defense applications, such as displays, batteries, communications, and physiological monitoring that could be embedded in soldiers' uniforms.

Because such devices can potentially be produced through additive processes such as printing, using roll-to-roll methods, another benefit will be a dramatic reduction in the production cost of many kinds of electronic devices. Most flexible electronics are also likely to be biodegradable and energy-saving, making major contributions to sustainability. Although estimates vary as to the eventual market for flexible electronics products, the range for potential revenues is pegged by informed observers at $75 billion to $190 billion.

OPPORTUNITIES AND CHALLENGES FOR THE UNITED STATES

The United States is in a strong position to compete successfully in the global flexible electronics industry. Universities and governments are already engaged in research that is directly relevant to flexible electronics, and the U.S. microelectronics industry is the world leader not only in technology but in manufacturing the most advanced devices.

Despite these and other strengths, however, the U.S. faces major challenges in establishing a strong manufacturing base in this emerging field. So far, most research and development in flexible electronics has been precompetitive. Repeated delays in commercializing flexible electronics technologies because of challenges in materials and manufacturing have affected both large electronics firms and startups.

In addition, major competitors in East Asia and Europe have launched targeted, large-scale programs with significant government funding to develop, refine, and manufacture these new technologies. In Europe, a major effort with broad technological scope has been underway since the late 1990s to develop commercially relevant processes and technology applications in flexible electronics, with extensive support from the European Union and very substantial national and regional efforts in the United Kingdom, Germany, the Netherlands, Belgium, and Finland. In East Asia, governments are working closely with large, established industrial groups possessing major financial resources and relevant industrial competencies to build a commanding global leadership position in flexible displays.

National and regional government funding in these areas of the world not only is much larger than current U.S. investment but also is more heavily weighted toward applied R&D. U.S. government funding for this field falls far short of government funding in Asia and Europe.

Perhaps most significantly, while the U.S. has developed an onshore supply chain to support flexible electronics manufacturing, no large U.S.-based champion has emerged that is prepared to engage in large-scale commercial manufacturing of products that integrate the various flexible electronics technologies being developed in the U.S. research base.

MEETING THE CHALLENGES AND MOVING FORWARD

Significant U.S. expansion in the market for flexible electronics is not likely to occur without mechanisms to mitigate investment risk, manage the sharing of intellectual property, and meet the diverse technology requirements associated with developing and manufacturing flexible electronics technologies. Linking industry, universities, and government offers the best prospect for achieving sufficient levels of investment and the acceleration of new technology development that is required to develop a vibrant flexible electronics industry.

The report recommends key actions to support these links and to maximize opportunities in flexible electronics:

- The United States should increase funding of basic research related to flexible electronics and augment support for university-based consortia to develop prototypes, manufacturing processes, and products in close collaboration with contributing industrial partners.
- Consortia, bringing together industry, universities, and various levels of government, should be used as a means of fostering precompetitive applied research in flexible electronics.
- The United States should establish and support a network of user facilities dedicated to flexible electronics.
- Where possible, federal efforts to support the growth of competitive flexible electronics industries should leverage state and regional developmental efforts, with the objective of establishing co-located local supply chains and capturing the associated cluster synergies.
- Agency mission needs should help drive demand for flexible electronics technologies, while lowering costs, improving capabilities, and contributing to the development of a skilled workforce.

COMMITTEE ON BEST PRACTICE IN NATIONAL INNOVATION PROGRAMS FOR FLEXIBLE ELECTRONICS

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For More Information . . . This Report Highlights was prepared by the Board on Science, Technology, and Economic Policy based on the report *The Flexible Electronics Opportunity*. The study was sponsored by the National Institute of Standards and Technology and the Department of Energy. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authoring committee and do not necessarily reflect those of the sponsors. Copies of the report are available from the National Academies Press, (800) 624-6242; **http://www.nap.edu**.

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