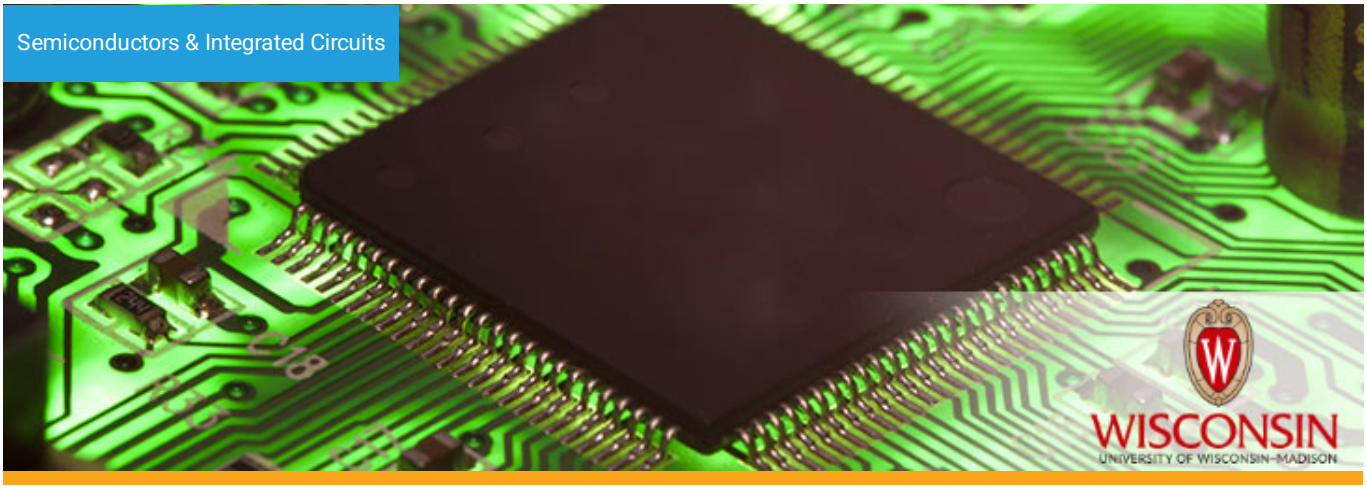


# Superior Nanotube Film for High Performance Field Effect Transistors

View U.S. Patent No. 9,368,723 in PDF format.

**WARF: P140200US01**

Inventors: Michael Arnold, Padma Gopalan, Gerald Brady, Yongho Joo

**The Wisconsin Alumni Research Foundation (WARF) is seeking commercial partners interested in developing a method to make a dense, highly aligned film of semiconducting single-walled carbon nanotubes.**

## Overview

Single-walled carbon nanotubes (SWCNTs) are key building blocks for nanoscale technologies given their interesting physical and chemical properties. SWCNTs are especially promising for high speed and low power semiconductor electronics. They can be directly grown via chemical vapor deposition techniques.

To make useful devices, SWCNTs must be formed into organized assemblies. Order is necessary because random arrangements don't function as well. Also, since two types of SWCNTs (metallic and semiconducting) are produced, it is important to be able to separate them. The semiconducting type (s-SWCNT) is particularly desirable for devices like field effect transistors (FETs).

Many methods have been explored to make and separate highly pure s-SWCNTs, for example, blown-bubble assembly, spin-coating, Langmuir-Blodgett methods, etc. While each of these methods has its strengths, a new and better approach is needed.

## The Invention

UW–Madison researchers have developed a method to make high density s-SWCNT film having good nanotube alignment. The film can be incorporated in high performance FETs.

The film is made using a method called dose-controlled, floating evaporative self-assembly. This method uses a thin layer of organic solvent containing solubilized s-SWCNTs that is spread over the surface of an aqueous medium, inducing evaporative self-assembly upon contact with a solid substrate.

The s-SWCNTs are applied in controlled 'doses,' which allows for the rapid sequential deposition of narrow films or 'stripes' with continuous control over width, density and periodicity. For this reason they are well suited for use as channel materials in FETs having high on-conductance values and high on/off ratios.

## Applications

- Field effect transistors, displays, sensors, biosensors and heterojunction devices (e.g., solar cells)

## Key Benefits

- High degree of nanotube alignment
- Highly dense and pure
- Method selects s-SWCNTs without the need for subsequent sorting.

- Rapid and cost effective

## Stage of Development

Semiconducting SWCNT film has been produced with 15 degree or better alignment, linear packing density of 40 nanotubes per micrometer and purity levels of at least 99.9 percent.

The development of this technology was supported by WARF Accelerator. WARF Accelerator selects WARF's most commercially promising technologies and provides expert assistance and funding to enable achievement of commercially significant milestones. WARF believes that these technologies are especially attractive opportunities for licensing.

## Additional Information

**For More Information About the Inventors**

- Michael Arnold
- Padma Gopalan

**Related Technologies**

- WARF reference number P110242US01 describes patterned graphene for field effect transistors.

**Related Intellectual Property**

- View Divisional Patent in PDF format.
- View Continuation Patent in PDF format.

**Publications**

- Brady G.J., Joo Y., Wu M-Y., Shea M.J., Gopalan P. and Arnold M.S. 2014. Polyfluorene-Sorted, Carbon Nanotube Array Field-Effect Transistors with Increased Current Density and High On/Off Ratio. ACS NANO 8, 11614–11621.
- Read a news story about this technology.
- Read another news story about this technology.
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**Tech Fields**

- Semiconductors & Integrated Circuits : Components & materials

For current licensing status, please contact Jeanine Burmania at jeanine@warf.org or 608-960-9846