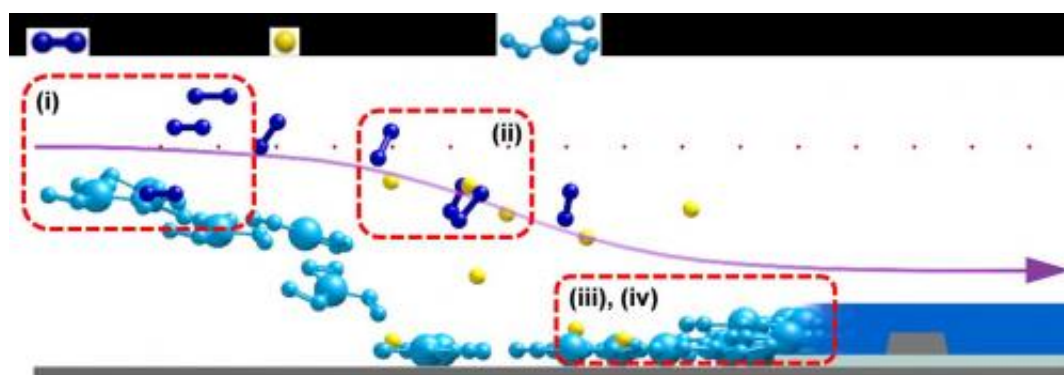


Team develops ultrathin polymer insulators key to low-power soft electronics

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Schematic image to show how the initiated chemical vapor deposition (iCVD) technique produces pV3D3 polymeric films: (i) introduction of vaporized monomers and initiators, (ii) activation of initiators to thermally dissociate into radicals, (iii) adsorption of monomers and initiator radicals onto a substrate, and (iv) transformation of free-radical polymerization into pV3D3 thin films. Credit: KAIST

A group of researchers at the Korea Advanced Institute of Science and Technology (KAIST) developed a high-performance ultrathin polymeric insulator for field-effect transistors (FETs). The researchers used vaporized monomers to form polymeric films grown conformally on various surfaces including plastics to produce a versatile insulator that meets a wide range of requirements for next-generation electronic devices. Their research results were published online in *Nature Materials* on March 9th, 2015.

FETs are an essential component for any modern electronic device used in our daily life from cell phones and computers, to flat-panel displays. Along with three electrodes (gate, source, and drain), FETs consist of an insulating layer and a semiconductor channel layer. The insulator in FETs plays an important role in controlling the conductance of the semiconductor channel and thus current flow within the translators. For reliable and low-power operation of FETs, electrically robust, ultrathin insulators are essential. Conventionally, such insulators are made of inorganic materials (e.g., oxides and nitrides) built on a hard surface such as silicon or glass due to their excellent insulating performance and reliability.

However, these insulators were difficult to implement into soft electronics due to their rigidity and high process temperature. In recent years, many researchers have studied polymers as promising [insulating materials](#) that are compatible with soft unconventional substrates and emerging semiconductor materials. The traditional technique employed in developing a polymer insulator, however, had the limitations of low surface coverage at ultra-low thickness, hindering FETs adopting polymeric insulators from operating at low voltage.

A KAIST research team led by Professor Sung Gap Im of the Chemical and Biomolecular Engineering Department and Professor Seunghyup Yoo and Professor Byung Jin Cho of the Electrical Engineering Department developed an insulating layer of organic polymers, "pV3D3," that can be greatly scaled down, without losing its ideal insulating properties, to a thickness of less than 10 nanometers (nm) using the all-dry vapor-phase technique called the "initiated chemical vapor deposition (iCVD)."



Transistor array fabricated on a large scale, highly flexible substrate with pV3D3 polymeric films. Credit: KAIST

The iCVD process allows gaseous monomers and initiators to react with each other in a low vacuum condition, and as a result, conformal polymeric films with excellent insulating properties are deposited on a substrate. Unlike the traditional technique, the surface-growing character of iCVD can overcome the problems associated with surface tension and produce highly uniform and pure ultrathin polymeric films over a large area with virtually no surface or substrate limitations. Furthermore, most iCVD polymers are created at room temperature, which lessens the strain exerted upon and damage done to the substrates.

With the pV3D3 insulator, the research team built low-power, high-performance FETs based on various semiconductor materials such as organics, graphene, and oxides, demonstrating the pV3D3 insulator's

wide range of material compatibility. They also manufactured a stick-on, removable electronic component using conventional packaging tape as a substrate. In collaboration with Professor Yong-Young Noh from Dongguk University in Korea, the team successfully developed a transistor array on a large-scale flexible substrate with the pV3D3 insulator.



Electronic component fabricated on a conventional packaging tape, which is attachable or detachable, with pV3D3 polymeric films embedded. Credit: KAIST

Professor Im said, "The down-scalability and wide range of compatibility observed with iCVD-grown pV3D3 are unprecedented for polymeric insulators. Our iCVD pV3D3 polymeric films showed an insulating performance comparable to that of inorganic insulating layers, even when their thickness were scaled down to sub-10 nm. We expect our development will greatly benefit flexible or soft electronics, which will play a key role in the success of emerging [electronic devices](#) such as wearable computers."

More information: Synthesis of ultrathin polymer insulating layers by initiated chemical vapor deposition for low-power soft electronics, [DOI: 10.1038/nmat4237](https://doi.org/10.1038/nmat4237)

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