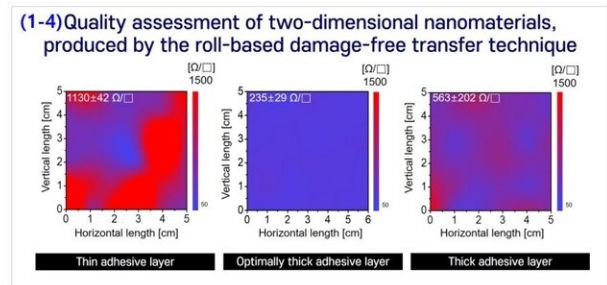
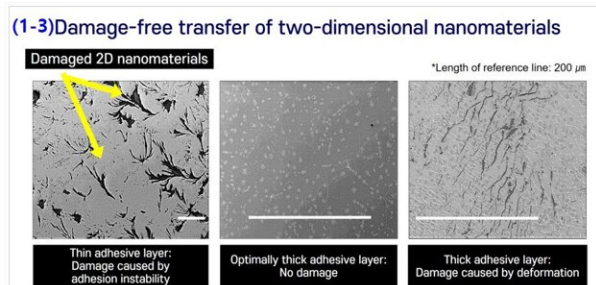
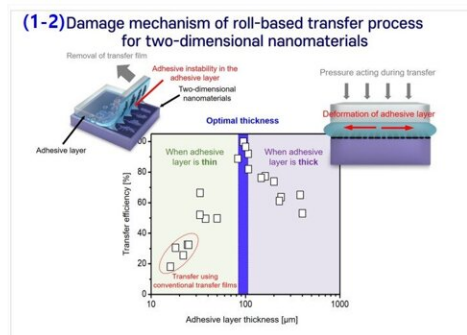
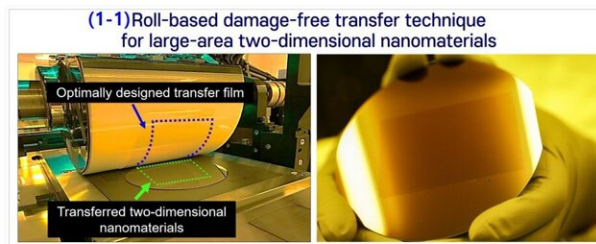


# Fast, affordable solution proposed for transparent displays and semiconductors

May 17 2021



(1-1) Dr. Kwang-Seop Kim and his research team at the Department of Nano-Mechanics, KIMM, have succeeded in developing the roll-based damage-free transfer technique for 2D nanomaterial (monolayer graphene). (1-2) Dr. Kwang-Seop Kim and his research team at the Department of Nano-Mechanics, KIMM, have revealed a damage mechanism of roll-based transfer process for 2D nanomaterials. If the adhesive layer is too thin, damage occurs to the 2D nanomaterials from adhesion instability; and if the adhesive layer is too thick, the contact pressure during the transfer process causes excessive deformation, causing damage to the materials. (1-3) Dr. Kwang-Seop Kim and his research team at the Department of Nano-Mechanics, KIMM, have succeeded in designing a transfer film with an optimally thick adhesive layer, and applied it to

the roll-based transfer process to successfully transfer 2D nanomaterial (monolayer graphene) to the desired substrate without damage.(1-4) A graph showing the sheet-resistance quality of 2D nanomaterial (monolayer graphene) based transparent electrodes, produced by the roll-based transfer technique. The lower the sheet resistance, the better it conducts electricity to transparent electrode (monolayer graphene); and the more uniformed the sheet resistance quality, the better one can make large-scale transparent electrode. When the adhesive layer is thin, the sheet resistance is extremely high at 1130 Ohm/sq., and the sheet resistance quality is non-uniform. When the adhesive layer is thick, the sheet resistance is 563 Ohm/sq., and the sheet resistance quality is again non-uniform. When using the transfer film designed to have an optimally thick adhesive layer, the sheet resistance is very low at 235 Ohm/sq., and the sheet resistance quality is uniform. Credit: The Korea Institute of Machinery and Materials (KIMM)

The Korea Institute of Machinery and Materials (KIMM) under the Ministry of Science and ICT developed a roll-based damage-free transfer technique that allows two-dimensional (2D) nanomaterials to be transferred into wafer scale without damage. The proposed technique has a variety of applications from transparent displays and semiconductors to displays for self-driving cars, and is expected to accelerate the commercialization of 2D nanomaterial-based high-performance devices.

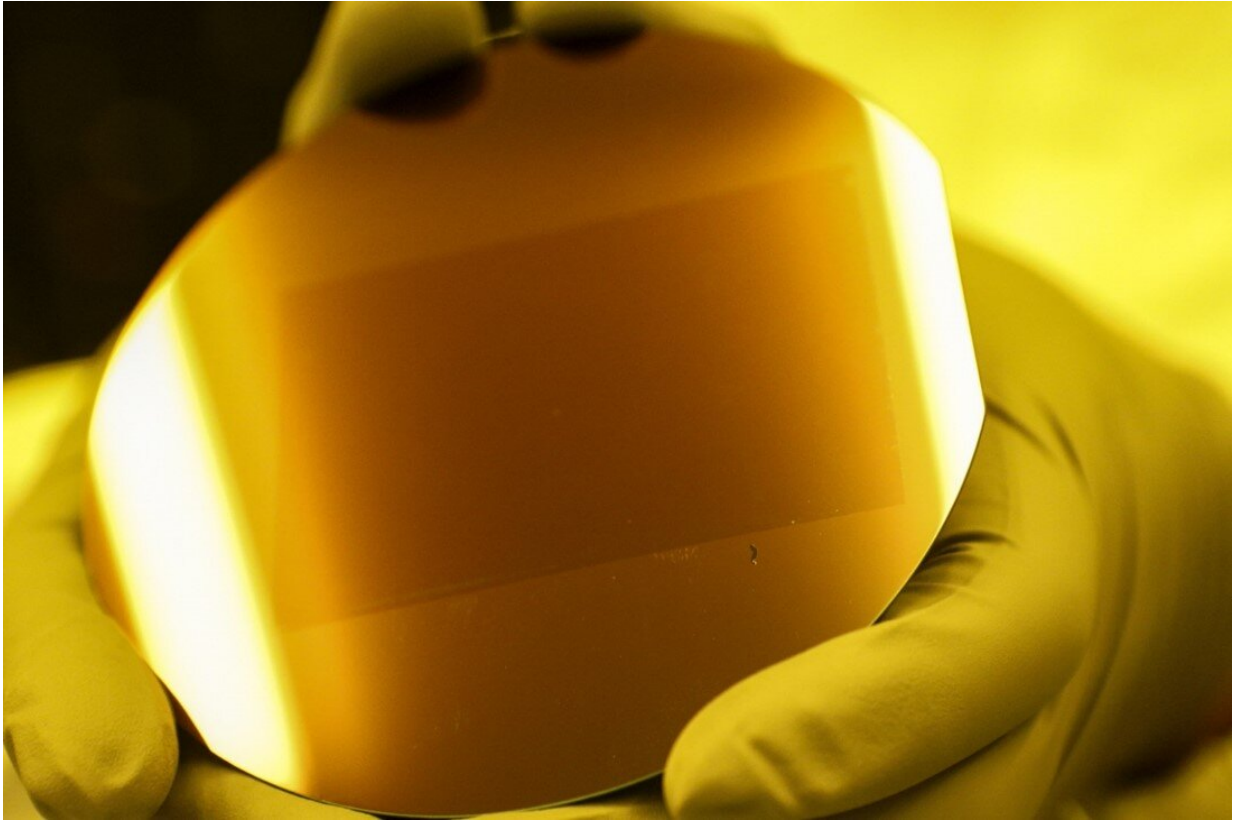
Dr. Kwang-Seop Kim, principal researcher of the Department of Nano-Mechanics at KIMM, succeeded in developing a technique of transferring 2D nanomaterials, as thin as 1/50,000 of a strand of hair, to a [substrate](#) of at least 4 inches (approx. 10 cm) without damage.

The roll-based transfer is a process in which 2D nanomaterials on a transfer film are transferred to a desired substrate. It is a highly efficient technique that enables large-area continuous transfer of nanomaterials,

similar to paper printing.

The transfer process involves nanomaterials on a transfer film (A) and a target substrate (B). In roll transfer, the nanomaterials are transferred to B when A is rolled onto B. This is similar to the process of transferring a tattoo onto skin using a tattoo sticker. The sticker plays the role of the transfer film, the tattoo represents the 2D nanomaterials, and the skin is the substrate.

The key point in the proposed technique is to identify two different types of the damage mechanisms in relation to the deformation of adhesive layer in the transfer film through computer simulation and experiments. The team optimizes the thickness of the adhesive layer to minimize the deformation of the adhesive layer during the transfer process, leading to achieve the damage-free transfer of large-area 2D nanomaterials.



The wafer produced by Dr. Kwang-Seop Kim and his research team at the Department of Nano-Mechanics, KIMM, using the roll-based damage-free transfer technique for 2D nanomaterials. Credit: The Korea Institute of Machinery and Materials (KIMM)

The team discovered the principle behind the damage-free transfer of an extremely thin tattoo to skin through optimizing the [tattoo](#) sticker.

The technique can be utilized in the roll-based transfer process for the production of 2D [nanomaterial](#)-based flexible [transparent displays](#) and transparent semiconductors, decreasing the damage in 2D nanomaterial down to 1% compared to the existing 30%.

Principal researcher Kwang-Seop Kim said, "Our technique of

transferring large-area 2D nanomaterials and micro-devices without damage to substrates will significantly lower manufacturing costs of wearable devices, flexible transparent displays, and high-performance bio/energy sensors, thus accelerating the commercialization of related applications. We also expect to see new businesses across industries from next-generation semiconductors to future vehicles."

**More information:** Chan Kim et al, Damage-free transfer mechanics of 2-dimensional materials: competition between adhesion instability and tensile strain, *NPG Asia Materials* (2021). [DOI: 10.1038/s41427-021-00311-1](https://doi.org/10.1038/s41427-021-00311-1)

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