

# Next-generation semiconductors synthesis

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Although silicon semiconductors are nearly universal in modern electronics, devices made from silicon have limitations—including that they cease to function properly at very high temperatures. One promising alternative are semiconductors made from combinations of aluminum, gallium, and indium with nitrogen to form aluminum nitride (AlN), gallium nitride (GaN), and indium nitride (InN), which are stronger and more stable than their silicon counterparts, function at high temperatures, are piezoelectric (that is, generate voltage under mechanical force), and are transparent to, and can emit, visible light.

Conventional processes for producing AlN layers run at temperatures as high as 1150 degrees Celsius, and offer limited control over the thickness of the layers. Now a new technique, described in the AIP Publishing journal *Applied Physics Letters*, offers a way to produce high-quality AlN layers with atomic-scale thickness and at half the temperature of other methods.

Neeraj Nepal and colleagues of the United States Naval Research Laboratory in Washington, D.C. formed AlN layers using atomic layer epitaxy (ALE), in which materials are "grown," layer-by-layer, by sequentially employing two self-limiting chemical reactions onto a surface.

"For instance to grow aluminum nitride, you would inject a pulse of an aluminum precursor into the growth zone where it would coat all surfaces," explained Nepal. "After purging any excess aluminum precursor away, you would then 'build' the crystal by injecting a pulse of

the nitrogen precursors into the growth zone, where it reacts with the aluminum precursor at the surface to form a layer of AlN. Then you'd purge any excess nitrogen and reaction products away and repeat the process."

With this process, the researchers produced a material with qualities similar to those synthesized at much higher temperatures, but under conditions that allow it to be integrated in new ways for the fabrication of devices for technologies such as transistors and switches.

The work, Nepal says, expands the potential for new advanced specialty materials that could be used, for example, in next-generation high-frequency radiofrequency electronics, such as those used for high-speed data transfer and cell phone services.

**More information:** The article, "Epitaxial Growth of AlN Films via Plasma-assisted Atomic Layer Epitaxy" by N. Nepal, S. B. Qadri, J. K. Hite, N.A. Mahadik, M.A. Mastro, and C. R. Eddy, Jr. appears in the journal *Applied Physics Letters*: [dx.doi.org/10.1063/1.4818792](https://doi.org/10.1063/1.4818792)

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