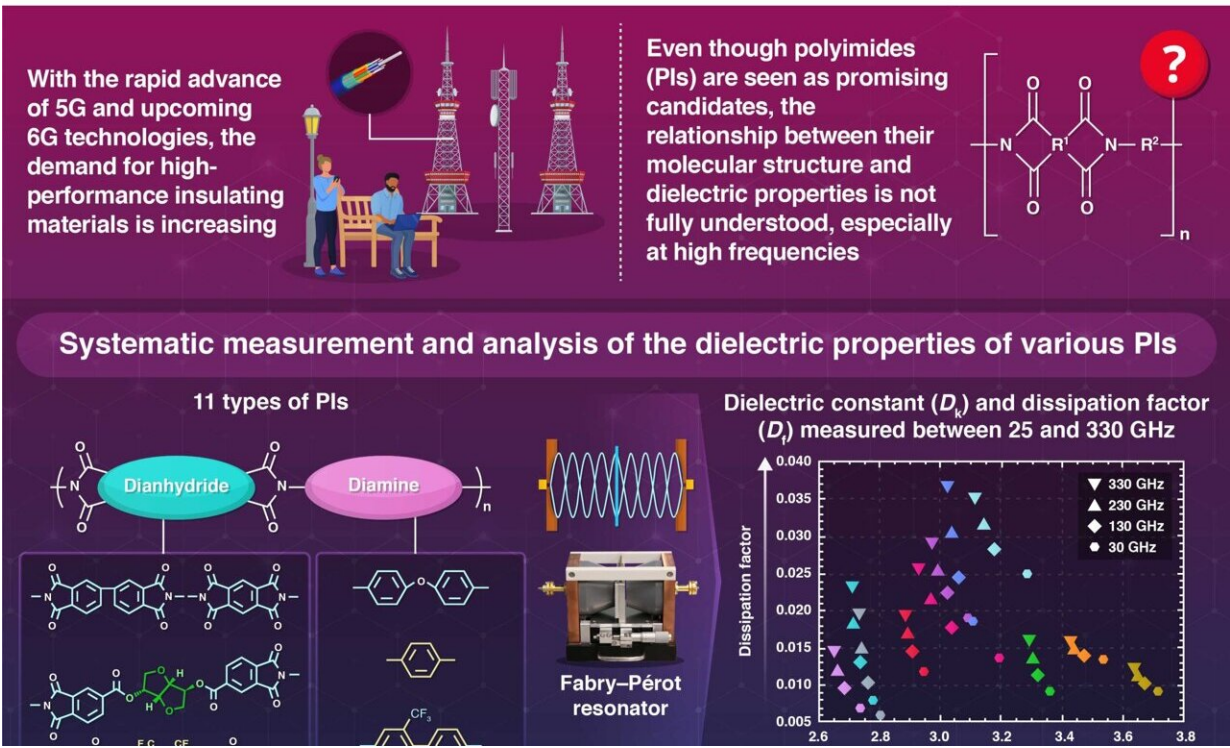


A deep dive into polyimides for high-frequency wireless telecommunications

July 26 2024

Paving the Way to Better Insulating Materials for 5G and 6G



These findings will serve as design pointers for high-performance dielectric materials for 5G and 6G applications. Credit: Tokyo Tech

As 5G technologies continue to evolve, scientists and engineers are already exploring new ways to turn things up a notch for 6G. One of the

biggest challenges to address in both 5G and 6G is the many detrimental effects that operating at extremely high frequencies has on wireless communications. At frequencies nearing the terahertz range, problems such as signal attenuation and interference are more prominent, and maintaining signal integrity becomes much harder.

Some of these issues can be greatly mitigated by using insulating materials with exceptional dielectric properties. Glass- and ceramic-based insulating materials currently dominate the scene, but their high cost and fabrication complexity render them largely unsuitable for mass-produced devices, which are needed for high-end 6G. Could polymeric materials be a better alternative?

In an effort to answer this question, a research team from Tokyo Institute of Technology conducted a study on polyimides (PIs), which are gaining traction as materials suitable for high-frequency operation. Led by Professor Shinji Ando and including Haonan Liu, the team's latest paper was [published](#) in *Applied Physics Letters* on June 6, 2024.

"Polyimides stand out because of their excellent thermal stability, mechanical toughness, flexibility, lightweight, and favorable dielectric properties. However, the correlation between the molecular structure of PIs and their dielectric properties has not yet been fully established," explains Ando. "Existing studies on the dielectric properties of PIs in the GHz frequency range are limited to below 60 GHz, which poses a severe hindrance to the design of pointers for next-generation dielectric PI materials."

The research team sought to address this knowledge gap by measuring and analyzing the dielectric properties of 11 PIs with different types of molecular structures. To this end, they used a device called a Fabry–Pérot resonator, which is currently the only known tool suitable for measuring the dielectric properties of thin films in the 110–330 GHz

range with a low dissipation factor.

Using the resonator, the researchers measured the dielectric constant (D_k) and the dissipation factor (D_f) of the polyimides. To clarify, both D_k and D_f are representative of a material's ability to store energy in different ways, and low values are critical for minimizing signal loss and maintaining signal integrity at [high frequencies](#).

All of the 11 PIs showed rather typical D_k and D_f curves, exhibiting a continuous decrease in these values as frequency increased. Notably, the PIs that contained higher fluorine content exhibited lower D_k values. In particular, a perfluorinated polyimide exhibited a significantly lower D_k and smaller D_f than the other polyimides, and the frequency dependence of D_k and D_f is also very small. Another particularly interesting discovery was that the increase in D_f was negatively correlated with the polar fraction—that is, the percentage of the polymer's mass made up of polar functional groups.

Taken together, the results of this study shed some much-needed light on the dielectric qualities of PIs. This data could eventually pave the way to faster and more reliable telecommunications by enabling engineers to tap into the [terahertz range](#) while overcoming the associated challenges. Of course, more efforts will be needed to identify the best type of PIs for these purposes.

"Spectroscopic studies in the THz range will help us indirectly infer the origins of the [dielectric](#) responses of different structural PIs at high frequencies," remarks Ando.

"Our findings will hopefully be beneficial for developing high-performance polymer-based insulating materials for 6G technologies," concludes Ando, with eyes on the future.

More information: Haonan Liu et al, Frequency-dependent dielectric properties of aromatic polyimides in the 25–330 GHz range, *Applied Physics Letters* (2024). [DOI: 10.1063/5.0205692](https://doi.org/10.1063/5.0205692)

Provided by Tokyo Institute of Technology

Citation: A deep dive into polyimides for high-frequency wireless telecommunications (2024, July 26) retrieved 27 July 2024 from <https://techxplore.com/news/2024-07-deep-polyimides-high-frequency-wireless.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.