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Ultralow *k* covalent organic frameworks enabling high fidelity signal transmission and high temperature electromechanical sensing

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As integrated circuits have developed towards the direction of complexity and miniaturization, there is an urgent need for low dielectric constant materials to effectively realize high-fidelity signal transmission. However, there remains a challenge to achieve ultralow dielectric constant and ultralow dielectric loss over a wide temperature range, not to mention having excellent thermal conductivity and processability concurrently. We herein prepare dual-linker freestanding covalent organic framework films with tailorable fluorine content via interfacial polymerization. The covalent organic framework possesses an ultralow dielectric constant (1.25 at 1 kHz, ≈1.2 at 6 G band), ultralow dielectric loss (0.0015 at 1 kHz) with a thermal conductivity of 0.48 $Wm^{-1}K^{-1}$. We show high-fidelity signal transmission based on the large-sized (>15 cm^2) COF films, far exceeding the most commercially available polyimide-based printed circuit board. In addition, the covalent organic framework also features excellent electret properties, which allows for active high-temperature electromechanical sensing. The electrode nanogenerator maintains 90% of the output voltage at 120 °C, outperforming the traditional fluorinated ethylene propylene electret. Collectively, this work paves the way for scalable application of ultralow dielectric constant covalent organic framework thin films in signal transmission and electromechanical sensing.

As the world enters the era of the Internet of Things (IoTs) and Artificial Intelligence (AI), ICs have rapidly evolved towards high complexity and miniaturization[1,2]. The advanced core chips typically integrate billions of transistors, and the average size of metal interconnects has shrunk to below 10 nanometers. Dense metal interconnects inevitably result in severe signal crosstalk and resistive (R) and capacitive (C) delays, thus leading to severe signal degradation and distortion during transmission, especially in high-frequency bands[3,4]. Therefore, we should urgently explore the next-generation ultralow dielectric constant (*k*) material to resolve these problems[5].

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