COMMUNICATION

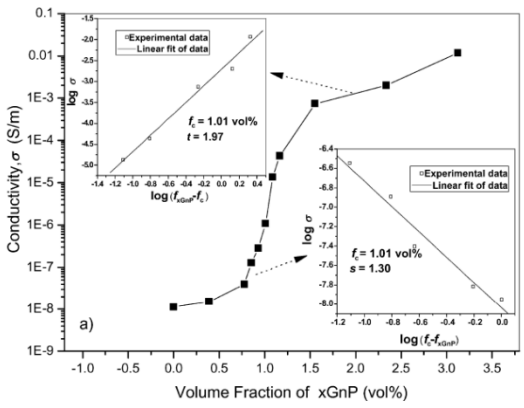

Figure 3. Effective conductivity of PVDF/xGnP nanocomposites as a function of xGnP volume fraction, measured at 1000 Hz and room temperature. The insets show the best fits of the conductivity to Equation 1.

transition) at $f_{xGnP} \approx 0.76–1.55$ vol%. The conductivity of the polymer/conductive-filler composites originates from two mechanisms: 1) Ohmic conduction, through direct contact of conductive fillers, and 2) non-Ohmic conduction, through the barrier-tunnelling effect between the conductive fillers separated by a polymer layer. The percolation transition can be seen as the transition from non-Ohmic conduction to Ohmic conduction, when the filler concentration approaches the percolation threshold.

The conductivity σ of the conductor-insulator composites near the percolation threshold can be predicted by the power laws in Equation 1a and b, as follows:

$$\sigma(f_{xGnP}) \propto (f_c - f_{xGnP})^{-s'} \quad \text{for } f_{xGnP} < f_c \tag{1a}$$

$$\sigma(f_{xGnP}) \propto (f_{xGnP} - f_c)^{t} \quad \text{for } f_{xGnP} > f_c \tag{1b}$$

In Equation 1, f_c is the percolation threshold, f_{xGnP} is the volume fraction of xGnP, and s' and t are the critical exponents in the insulating ($f_{xGnP} < f_c$) and conducting ($f_{xGnP} > f_c$) region, respectively. The best fits of the experimental conductivity values to the log–log plots of the power laws give $f_c = 1.01$ vol%, $t = 1.97$, and $s' = 1.30$ (see the insets in Fig. 3). The critical exponent in the conducting region, $t = 1.97$, is in agreement with the universal ones ($t_{un} \approx 1.6–2$). However, the critical exponent value in the insulating region, $s' = 1.30$, is higher than the universal value ($s_{un} \approx 0.8–1$), but close to that of PVDF/Ni composites.[14,22]

A giant increase in the dielectric constant near the percolation threshold can be obtained, as predicted by the percolation theory. As shown in Figure 4, the dielectric constant improved dramatically, and up to more than 200 when $f_{xGnP} = 1.01$ vol%, which is 20 times larger than that of pure PVDF (about 10). As far as the dielectric loss is concerned, an abrupt increase was observed near the percolation threshold (see the bottom right inset of Fig. 4), which is expected due to the formation of conductive paths within the nanocomposites. At $f_{xGnP} = 1.01$ vol%, the dielectric loss was 0.48, which is still acceptable for applications such as high-charge storage capacitors. As f_{xGnP} increased beyond the percolation threshold, the dielectric constant of the PVDF/xGnP nanocomposites continued to rise, to an exceptionally high value of about 4.5×10^7 at 1000 Hz,[23] although at this point the dielectric loss was also high (229). This high-dielectric-permittivity

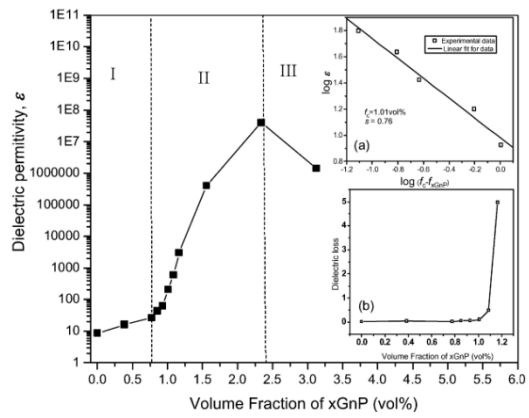

Figure 4. Effective dielectric constant of the PVDF/xGnP nanocomposites as a function of the xGnP volume fraction, measured at 1000 Hz and room temperature. Inset a) shows the best fits of the conductivity to Equation 2. Inset b) shows the loss tangent of PVDF/xGnP nanocomposites as a function of xGnP volume fraction.

Structured Extraction

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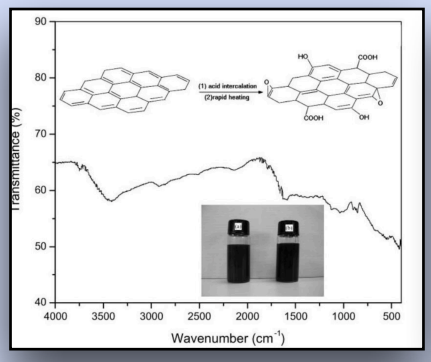
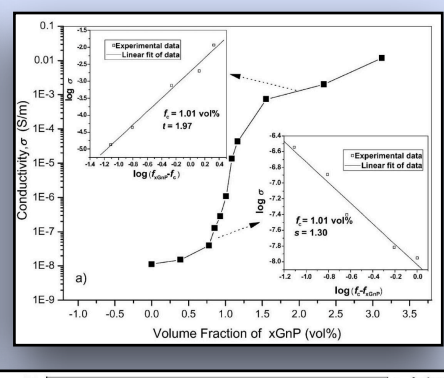
PDF to LaTeX

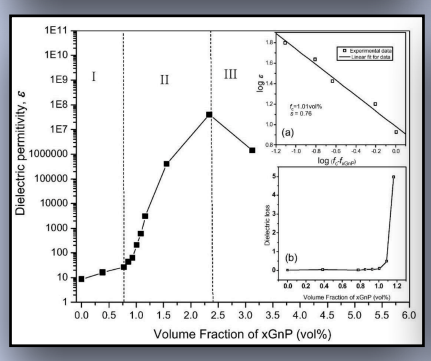
Text

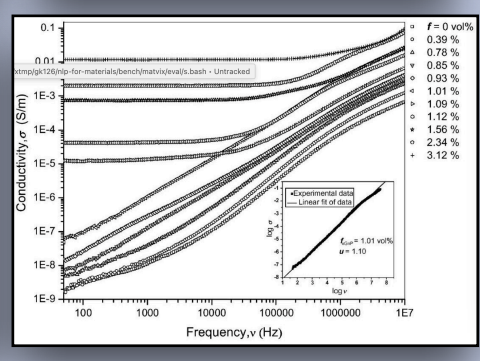
TEX

Images







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\title{High Dielectric Permittivity and Low Percolation Threshold in Nanocomposites
Based on Poly(vinylidene fluoride) and Exfoliated Graphite Nanoplates }

\author{By Fuan He, Sienting Lau, Helen Laiwa Chan, and Jintu Fan*}

\begin{document}
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Ferroelectric polymers, such as poly(vinylidene fluoride) (PVDF), poly(vinylidene
fluoride-co-trifluoroethylene) (P(VDF-TrFE)), and poly(vinylidene
fluoride-trifluoroethylene-chlorofluoroethylene) (P(VDF-TrFE-CFE)) have great
potential for applications in micro-electromechanical devices and high-charge
storage capacitors ${ }^{[1-3]}$

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Figure 1c shows the transmission electron microscopy (TEM) image of a $\mathrm
{PVDF} / \mathrm{xGnP}$ nanocomposite obtained from solution casting. Clearly, the
graphite nanoplates were well dispersed in the PVDF matrix without any aggregation,
which can be ascribed to specific interactions between the functional groups of the
$x G n P s$ and the $-\mathrm{CF}_{2}$ - group of the PVDF.

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