Supplementary

Porous PVDF as effective sonic wave driven nanogenerators

Calculation of an effective piezoelectric coefficient

The equations of 2mm symmetry for PVDF relating its electric and elastic variables can be written as following. Note that the applied stress is transferred via the PVDF to the substrate. Consequently, one can calculate the strains S_1 and S_2 as a function of T_3 depending on the PVDF geometry (Hooke's law was used here assuming that the PVDF is, in general, anisotropic with different proportionality factors such as $-k_1$ in the x direction and $-k_2$ in the y direction respectively.

$$S_1 = s_{11}{}^E T_1 + s_{12}{}^E T_2 + s_{13}{}^E T_3 + d_{31} E_3 = -k_1 T_3 \quad \text{(S-1)}$$

$$S_2 = s_{12}{}^E T_1 + s_{22}{}^E T_2 + s_{23}{}^E T_3 + d_{32} E_3 = -k_2 T_3 \quad \text{(S-2)}$$

$$S_3 = s_{13}{}^E T_1 + s_{23}{}^E T_2 + s_{33}{}^E T_3 + d_{33} E_3 \quad \text{(S-3)}$$

$$D_3 = \varepsilon_3 E_3 + d_{31} T_1 + d_{32} T_2 + d_{33} T_3 \quad \text{(S-4)}$$

From a definition of effective d_{33}, it can be expressed as

$$(\frac{\partial D_3}{\partial T_3})_E = d_{33} + d_{31}(\frac{\partial T_1}{\partial T_3})_E + d_{32}(\frac{\partial T_2}{\partial T_3})_E \quad \text{(S-5)}$$

And using eq. (S-1) and (S-2), $(\frac{\partial T_1}{\partial T_3})_E$ and $(\frac{\partial T_2}{\partial T_3})_E$ can also be calculated as

$$(\frac{\partial T_1}{\partial T_3})_E = -\frac{s_{12}{}^E}{s_{11}{}^E}(\frac{\partial T_2}{\partial T_3})_E - \frac{s_{13}{}^E + k_1}{s_{11}{}^E} = \frac{\frac{s_{12}{}^E}{s_{11}{}^E}\left(\frac{s_{23}{}^E + k_2}{s_{22}{}^E}\right) - \frac{s_{13}{}^E + k_1}{s_{11}{}^E}}{1 - \frac{\left(s_{12}{}^E\right)^2}{s_{22}{}^E s_{11}{}^E}} \quad \text{(S-6)}$$

$$(\frac{\partial T_2}{\partial T_3})_E = -\frac{s_{12}{}^E}{s_{22}{}^E}(\frac{\partial T_1}{\partial T_3})_E - \frac{s_{23}{}^E + k_2}{s_{22}{}^E} \quad \text{(S-7)}$$

By combining eq. (S-5) - (S-7), the effective d_{33} is then obtained as

$$d_{33}^{eff} = d_{33} + \left(d_{31} - \frac{d_{32}s_{12}^{E}}{s_{22}^{E}} \right) \left(\frac{ \frac{s_{12}^{E}}{s_{11}^{E}} \left(\frac{s_{23}^{E} + k_2}{s_{22}^{E}} \right) - \frac{s_{13}^{E} + k_1}{s_{11}^{E}} }{ 1 - \frac{\left(s_{12}^{E}\right)^2}{s_{22}^{E} s_{11}^{E}} } \right) - d_{32} \left(\frac{s_{23}^{E} + k_2}{s_{22}^{E}} \right) \tag{S-8}$$

where

$$s_{13}^{E} + k_1 = \frac{-s_{11}^{E}T_1 - s_{12}^{E}T_2 - d_{31}E_3}{T_3}, \quad s_{23}^{E} + k_2 = \frac{-s_{12}^{E}T_1 - s_{22}^{E}T_2 - d_{32}E_3}{T_3} \tag{S-9}$$

By combining eq. (S-8) and (S-9), inversely one can obtain E_3 as follows.

$$E_3 = \frac{ d_{33}^{eff} - d_{33} + \left(\frac{AB}{s_{22}} - \frac{d_{32}}{s_{22}} \right) \left(\frac{s_{12}T_1 + s_{22}T_2}{T_3} \right) + \frac{A}{s_{11}} \left(\frac{-s_{11}T_1 - s_{12}T_2}{T_3} \right) }{ \left(\frac{AB}{s_{22}} - \frac{d_{32}}{s_{22}} \right) \left(\frac{-d_{32}}{T_3} \right) + \frac{Ad_{31}}{s_{11}T_3} } \tag{S-10}$$

where

$$A = \frac{ d_{31} - \frac{d_{32}s_{12}}{s_{22}} }{ 1 - \frac{s_{12}^{2}}{s_{22}s_{11}} } \text{ and } B = \frac{s_{12}}{s_{11}} \tag{S-11}$$

Therefore, the piezoelectric potential can then be expressed as

$$V = -\int_{0}^{5\mu m} \left(\frac{ d_{33}^{eff} - d_{33} + \left(\frac{AB}{s_{22}} - \frac{d_{32}}{s_{22}} \right) \left(\frac{s_{12}T_1 + s_{22}T_2}{T_3} \right) + \frac{A}{s_{11}} \left(\frac{-s_{11}T_1 - s_{12}T_2}{T_3} \right) }{ \left(\frac{AB}{s_{22}} - \frac{d_{32}}{s_{22}} \right) \left(\frac{-d_{32}}{T_3} \right) + \frac{Ad_{31}}{s_{11}T_3} } \right) dz \tag{S-12}$$

Piezoelectric potential measurement under the same stress

Systemic measurement of strain confinement effect in PNG structure was carried out under the same stress. Top surface area of each inter-pore distance sample is varied because of the different number of pores in the same substrate size (1 cm^2). When the surface area of the bulk was set to 1, the top surface area ratio is varied by 1 to 0.28 times as the inter-pore distance varies from the bu1k (no pore, reference) to 300 nm. Therefore, the input sonic powers are controlled 88.9 dB to 100 dB to apply the same stress.

Inter-pore distance (nm)	Top surface area ratio	Input power (dB)
300	0.28	88.9
500	0.39	91.9
1000	0.60	95.6
5000	0.94	99.4
bulk	1	100

Table S-1: The input powers as the surface area ratio to apply the same stress on the PNGs