Aerosol-deposited functional films and composites on flexible polyimide for energy storage and caloric cooling applications

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To miniaturize functional devices, electroceramic components need to be scaled down to micrometer level. The aerosol deposition (AD) method offers a cost-efficient way to deposit dense, micrometer-thick films at room temperature, enabling the integration of ceramic components onto polymer or metal substrates. In this work, aerosol-deposited $0.9Pb(Mg_{1/3}Nb_{2/3})O_3–0.1PbTiO_3$ (PMN–10PT) thick films are integrated on flexible polymer substrates (Fig. 1). The films exhibit a relaxor-like hysteresis loop of polarization versus electric field, with high electrical breakdown strength, enabling recoverable energy densities of 10 $J·cm^{-3}$ at electric fields 1000 $kV·cm^{-1}$. The energy-storage response remains stable after 10^5 bending cycles at ~1% bending strain [1]. The films also show promising caloric performance [2]. In particular, the composite film based on the electrocaloric PMN–10PT and the magnetocaloric La-Fe-Si-based intermetallic alloy exhibits a 32% enhancement in electrocaloric performance relative to PMN–10PT thick films alone. The enhancement is attributed to Maxwell-Wagner polarization effects, induced by the embedded magnetocaloric phase [3]. Finally, lead-free $BaTiO_3$-based alternatives [4] will be addressed.

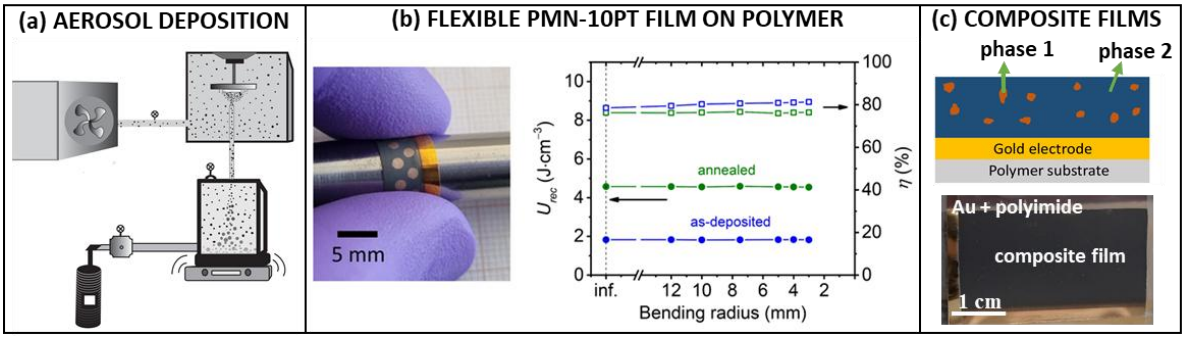

Fig. 1. (a) Aerosol deposition process, (b) PMN–10PT thick film on a polymer substrate and their recoverable energy density (U_{rec}) and efficiency (η) versus bending radius measured at ~500 $kV·cm^{-1}$ [6] (c) PMN–10PT/La-Fe-Si-based intermetallic alloy composite thick film on polymer substrate.

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[3] V. Regis, H. Uršič et al., submitted to J. Eur. Ceram. Soc., 2026
[4] S. Merselmiz, H. Uršič et al., Acta Materialia 304, 121749, 2026.