

NOVEL MATERIALS AS SENSORS OR ACTUATORS FOR DIGITAL-TWIN TECHNOLOGIES

YUNCHE WANG^{*} AND YATHORSON SAPSATHIARN[†]

^{*} Department of Civil Engineering, National Cheng Kung University
1 University Road, Tainan, Taiwan
yunche@ncku.edu.tw and <https://web.ncku.edu.tw>

[†] Department of Civil and Environmental Engineering, Mahidol University
25/25 Puttamonthon, Salaya, Nakorn Pathorn, 73170, Thailand
yasothorn.sap@mahidol.edu and <https://mahidol.ac.th>

ABSTRACT

Novel materials can serve as sensors or actuators within the closed feedback loop of digital-twin technologies. Hence, desired passive material properties, such as elastic modulus, Poisson's ratio, mass density, electric permittivity, magnetic permeability, thermal conductivity, heat capacity, and others, are critical to the successful deployment of a digital-twin service. Furthermore, active materials may provide actuation as the digital-twin control demands. Thermodynamic bounds must be satisfied in the passive materials. However, when materials are allowed to have internal microstructures and processes, they may exhibit negative characteristics, such as negative stiffness due to postbuckling processes or in Landau phase transitions. Several physical considerations, such as violation of conservation laws in the non-Hermitian, non-reciprocal systems, or odd elasticity, are adopted to examine their stability or exceptional points, where eigenvalues change from real to complex numbers as internal variables are suitably tuned. Possible applications of materials with negative characteristics are abundant, e.g. vibration mitigation, noise reduction, cloaking in electromagnetic/acoustic/elastic waves, or unbounded effective material properties in composites. In this minisymposium, all aspects, numerical, theoretical, and experimental viewpoints in understanding such materials are welcome, including but not limited to machine learning techniques to generate internal microstructures or mechanisms, and novel analytical or computational methods in calculating physical properties for materials in solid, liquid, or other states. Experimental or theoretical studies to correlate numerical results are also welcome.

Keywords: active materials, passive materials, sensors, non-reciprocal, non-Hermitian