ME Seminar

Theory-driven discovery of materials

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ABSTRACT

Functional materials stand out from traditional materials by exhibiting some unprecedented macroscopic properties. These exceptional properties make them extremely useful in wide-ranging applications such as efficient energy conversion, soft robotics and design of quieter jet engines. In my work, I use mathematics and mechanics for a deeper understanding of functional materials. This fertile interaction between materials science, mathematics and mechanics not only refines the understanding of these materials, but also leads to the discovery of new materials with remarkable properties. In this talk, I will present my work on three interesting classes of functional materials.

We begin with a class of materials known as shape memory alloys (SMAs). SMAs owe their unusual properties to the material undergoing a martensitic phase transformation. We shall discuss the crucial role of mechanical compatibility and its theoretical implications leading to the discovery of $Au_{30}Cu_{35}Zn_{45}$. This alloy displays exceptional properties despite undergoing a big first order phase transformation.

The next class of functional materials that I will present are ferromagnets. Ferromagnets, by far, are the most important class of functional materials and are found in applications ranging from electric motors to smartphones. In particular, we shall focus on the recent experiments on Galfenol ($Fe_{83}Ga_{17}$). Galfenol is a ferromagnet known for its large magnetostriction while under large tensile loads. We will see its peculiar magnetic microstructure and its consequences on the macroscopic properties of the ferromagnet.

Finally, I will talk about the last class of functional materials known as magnetorheological elastomers (MREs). MREs are a relatively new category of composite materials comprising of ferromagnetic microparticles in a soft polymeric matrix. MREs have some important advantages over traditional ferromagnets but modeling them poses challenging computational problems. These materials exhibit complex magneto-mechanical coupling. Based on the material parameters from the experiments conducted on slender structures composed of MREs, we propose a novel strategy where the magnetic solution precedes the elastic component of the problem.

ABOUT THE SPEAKER

Vivekanand Dabade is an Assistant Professor in the Department of Aerospace Engineering at IISc, Bangalore. Prior to this he was a Postdoctoral Research Scholar in Laboratoire de Méchanique des Solides at École Polytechnique, France. He received his Ph.D. in Aerospace Engineering and Mechanics from the University of Minnesota in 2017. Vivek is a recipient of the Doctoral Dissertation Fellowship from the University of Minnesota and the US Junior Oberwolfach Fellowship. His research interests lie in the development of novel materials by engineering the microscopic structure of the materials.

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