# Magnetic control of arbitrarily shaped objects with Gallium-Based Transitional Ferrofluid

Cheng, Jiashu (School: Culver Academies)

Magnetic control can be used as a method of remote manipulation. However, despite being precise, far-reaching, and instantaneous, it is inconvenient and limited as only ferromagnetic materials can be affected by the magnetic field. This project sought to address the problem through an innovative method enabling magnetic control on arbitrarily shaped non-magnetic objects (plastic, organic materials, etc.) via a transitional ferrofluid (TF) grasper. The TF is fabricated through the dispersion of Fe particles in Ga, which is enabled in concentrated HCl solutions. The composite material has a stiffness of 3.6GPa at solid state in room temperature and upon moderate heating (T>Tm=29.8 degrees Celsius), is able to transform into liquid state. With rapid phase change and drastic difference in the interlocking force that follows (up to 1168.42N in solid state and 0.01N in liquid state), the TF, transitioning from liquid to solid state, can be applied as a temporary magnetic grasper enabling magnetic control over non-magnetic objects. It can then be removed through melting after manipulation. The project further investigated the remote heating effects by Alternating Magnetic Field on the TF. The results demonstrated high efficiency when TF is remotely heated via AMF (after 60s of heating, temperature change is 5 times that of pure Ga). This project displayed promising potentials for developing methods of remote control in areas including aerospace industry, biomedical engineering, and soft robotics.