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Abstract
Autonomous Experimentation Applied to Carbon Nanotube Synthesis,
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We have developed a first-of-its-kind Autonomous REsearch System (ARES) capable of designing, executing, and analyzing its own experiments autonomously. The closed loop, iterative method enables ARES to design new experiments based on prior results dynamically, after each experiment; a first for materials research.

We are applying this method to understand and control the synthesis of single wall carbon nanotubes, in this case optimizing growth rate in (7) - dimensional parameter space. We use automated in situ Raman spectroscopy characterization of growth rate for CVD synthesis of carbon nanotubes as a metric for a target objective used by our NMD-M3 artificial intelligence planner. NMD-M3 uses a random forest learning approach which models experimental results as a function of experimental inputs, and a genetic algorithm planner to propose new experiments expected to achieve the targeted growth rate.

We expect ARES to be a disruptive advance in the near future, combining advances in robotics, artificial intelligence, data sciences and in operando methods to enable us to attack high dimensional research problems that were previously intractable by current research processes. Already we are applying the ARES method to multiple problems, including Additive Manufacturing and defect engineering in graphene.

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