Thesis Project Portfolio

Electrical Discharge Machining (EDM) Prototype

(Technical Report)

Revitalizing Domestic Semiconductor Manufacturing in the United States: Prospects of The Chips Act in Reestablishing US Semiconductor Supply

(STS Research Paper)

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Sociotechnical Synthesis

A shortage in semiconductor supply is currently forming obstructive and detrimental impacts upon the United States's electronic infrastructure in a multitude of areas. This shortage has progressively developed over the past three decades, and worsened through the turn of the 2020s. Shortage development grew gradually at first, due to US firms offshoring the manufacturing process for chip fabrication, and losing market control to international partnering firms. However, trade-war deterioration in relations between the US and China, alongside major production setbacks from quarantine closures during the COVID-19 pandemic, have recently created a sharp spike in the shortage's severity. In response to the shortage's severity, the US Federal Government approved The Chips Act as law in August of 2022. This act devoted 52.7 billion dollars of federal money towards creating domestic manufacturing plants, research and development (R & D), chip design compatibility with emerging technology, educational training of workforce, and consortium collaboration for technological improvement within semiconductors. The STS paper synthesized in my research evaluates the prospects of The Chips Act in achieving its intended aims for recovering, restabilizing, and resecuring the US's semiconductor industry. As an example of this act's importance, the technical project synthesized in my research details semiconductor application to aeronautical manufacturing. My technical project applies semiconductors by small-scale prototyping an Electrical Discharge Machine (EDM). The research used within my STS paper is gathered through the conceptual lenses of techno-nationalism, and techno-globalism.

My technical project involved building an EDM that eroded a channel into an aluminum workpiece. Electrical Discharge Machining is a manufacturing process that involves discharging electrical arcs across a dielectric medium, and through a metal workpiece. In the machine,

electrical discharge at high voltage causes a metal workpiece to conduct electrons streaming at a high velocity. In turn, this velocity converts to thermal kinetic energy, when workpiece material conductivity is exceeded. The thermal energy heats up a gap between the electrode tool and workpiece, resulting in the formation of plasma channel. Contact between the hot plasma and workpiece causes surface material from the workpiece to transition out of solid state. At the end of electrical discharge, the unsolidified material reforms as solid byproduct bits which are cleared from the workpiece. The depth of a channel is gradually eroded within the workpiece as an outcome to this process. EDM is used in the aeronautical industry to manufacture regenerative cooling channels in the nozzle and combustion chamber of a rocket. This regenerative cooling circulates liquid coolant in the frame around a rocket's engine to absorb emitted heat. Continuously cooling the surrounding area of a rocket's heat sources serves to increase rocket efficiency through heat moderation, and prolong the usability life of rocket engines through reduction of thermal strain. The small-scale EDM prototype of my group is designed for use by small-scale aeronautical researchers, hobbyists, and college rocketry projects such as UVA's High Powered Rocketry Club.

The research of my STS project assessed the prospective impacts of The Chips Act on mainly the US's domestic semiconductor supply. I first discussed how the act would impact both the supply adequacy, and vertical supply chain of fabrication materials (fabs). Then, I examined the act's funding of research and development (R & D) for semiconductor chips. After introducing these topics, I delved into the progression and effect of the semiconductor consortium called SEMATECH for a case study. I compared the approaches to domestic semiconductor revitalization that The Chips Act and SEMATECH have both taken, and connected how SEMATECH's successes and shortcomings foretell the act's likely impacts on the US. Next, I analyzed the significance of each impact made upon the US by the act. Using the STS lenses of techno-

nationalism and techno-globalism, I analyzed the act's consequent effects on US consumerism, national security, military capacity, and technological capability. My research indicated that The Chips Act would serve as a relief to present shortages, and a groundwork for supply chain revamping. The act won't enable the US to achieve autarky in semiconductors, but it will revamp America's supply chain such that the US can have a consistent and untainted supply of semiconductors.

The ability to complete my group's technical project is an example of a capability held by semiconductors. Transistors within the circuit board of the EDM machine would not be able to function without semiconductors. Without operative EDM, the US would not be able to manufacture decent rockets, or substantially train its aeronautical engineers. Rocket capabilities, and their implications to America's space program, underscore semiconductors' importance to vital national interests of the US.