INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Ultrafast modifications of graphitic carbon nanostructures and nanohybrids for energy storage and catalysis

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SHORT ABSTRACT

This thesis introduces transient Joule heating (TJH) as a novel, ultrafast, energy-efficient, and cost-effective strategy for synthesizing advanced materials critical for a clean and sustainable energy future. By employing millisecond current pulses, TJH overcomes the limitations of traditional high-temperature, time-consuming material processing. The research demonstrates TJH's versatility across two key applications: rapid fabrication of high-performance supercapacitor electrodes, such as multimodal porous graphene and MOF-derived porous graphitic nanoleaves, which yield high areal capacitance and energy density for robust symmetric and flexible solid-state supercapacitors suitable for wearable electronic devices. Additionally, TJH facilitates the precise synthesis of efficient electrocatalysts for hydrogen evolution reaction (HER) through a two-step process involving transient electro-graphitization (TEG) and thermal shock. This results in superefficient ruthenium (Ru)-based catalysts (e.g., ultrasmall amorphous Ru nanoclusters) and highly active, low-cost earth-abundant transition metal catalysts that exhibit state-of-the-art HER performance with low overpotentials and exceptional durability. Ultimately, this work establishes TJH as a transformative processing technique that significantly reduces thermal budgets and processing times, offers precise control over material properties, and maximizes atomic utilization of catalysts, providing a scalable and facile pathway for developing next-generation materials for energy storage and conversion applications.