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U.S. Department of Energy's
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Chai Peddeti working with the mass spectrometer. Photo credit: AJ Gubser

From "Don't Know" to Doctorate

The COVID-19 virus put a lot of things on hold, including people's lives.

"I graduated with my master's right at the start of the pandemic," said Chai Peddeti, a nuclear engineering student at University of California, Berkeley. Like many around the world, Peddeti was not sure what to do, until he received an important call.

"His name is Peter Hosemann," said Peddeti. "He called me in August and said, 'I really enjoyed working on our master's project with you' and he invited me to work on some projects with him as a Ph.D. student."

Peddeti double majored in physics and Japanese language and culture as an undergraduate. He fell in love with accelerators and one of his Japanese professors, Mariko Kawaguchi, connected him with a friend who helped him get his first position at Michigan State University's Facility for Rare Isotope Beams.

> Because I studied Japanese, I ended up in the nuclear field," Peddeti said, "you really don't know what's going to happen but I'm here because of that, so I'm always thankful and I'll never take that for granted.

Peddeti never seriously considered a Ph.D. but was excited about the project Hosemann described. His journey was now taking another unexpected turn.

"Something in my mind said, 'Hey, you know what? Let's try this nuclear material stuff,'" said Peddeti. "I went and got an essential workers permit and started on the NEUP FLAME-CAMP project."

FLAME-CAMP stands for Femtosecond Laser Ablation Materials Examination Center for Active Materials Processing. The project is funded by the Department of Energy Nuclear Energy University Program (NEUP) and is focused on small-scale testing of radiation on hot fuel rods at the university level.

"The idea is to use lasers to characterize burnup in hot fuel rods," said Peddeti. "What I mean by characterize is somehow give a tangible value to this material to describe how it has changed throughout its life cycle due to intense radiation, extreme heat, or other processes."

This kind of testing often requires capabilities found at national laboratories. "You need the shielding and all the expensive equipment," said Peddeti.

> "They came up with a way to perform post-irradiation examination on a small scale and still contribute to an existing nuclear database."

Peddeti's team aims to find out how much information they can gather from small materials. They came up with a way to perform post-irradiation examination on a small scale and still contribute to an existing nuclear database. The "how" is where FLAME-CAMP's long acronym comes into play.

"We built a system, a foot-long acrylic box with some metal components that is equipped to hold a nuclear rod," Peddeti said.

This airtight box allows the team to spin the rod within the box while a femtosecond laser shoots the rod through a glass viewpoint. Spinning the rod allows the laser to hit different points of the specimen. When the laser hits the fuel rod, it creates a plasma that is transferred to a mass spectrometer, which reads the plasma and debris from the laser shot and reports the isotopic information of the material.

"It'll tell you that 'there's iron in this rod, there's zirconium in this rod,' but even deeper than that it tells you the specific isotopes. For example, uranium-235, uranium-238, or plutonium-239."

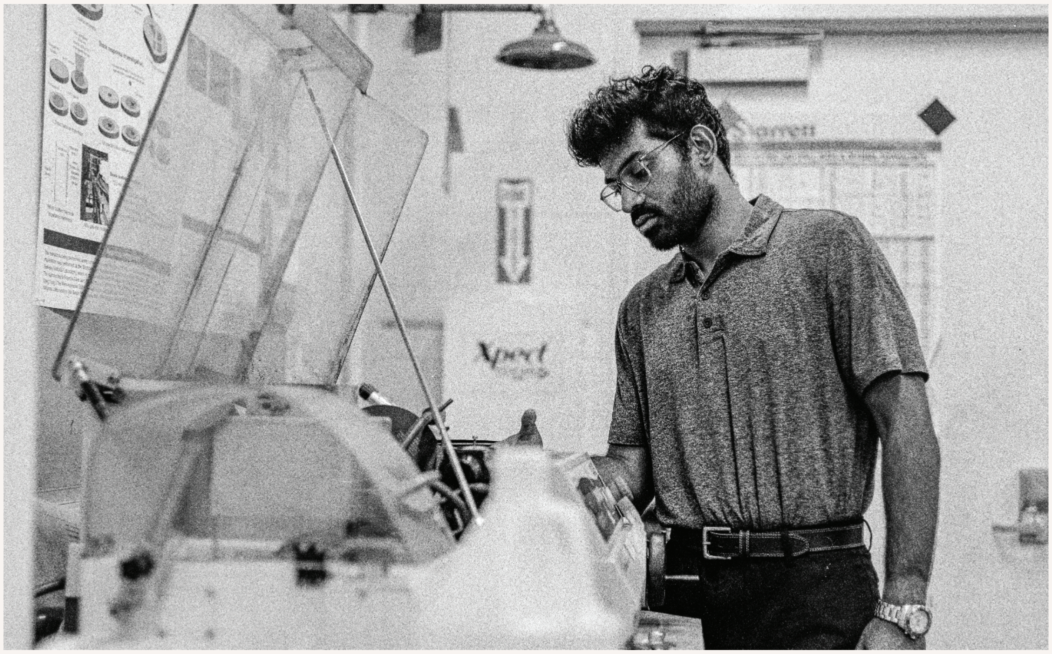
Understanding the concentration of each isotope allows the team to determine how efficiently the fuel was used in a specific setting.

> "This is important in terms of how we design fuels, how we design reactor assemblies based on specific ratios of isotopes we measure," Peddeti said. "It ultimately tells us how efficiently the fuel was used up."

Performing this kind of testing at the university level has been a huge win and is well received by the nuclear industry.

Hosemann, the principal investigator and mentor, said quantifying the elements and isotopes in the material while cutting and processing samples for further microstructure investigation in air using light through a glass window without touching it is almost like magic.

"This is a success story for NEUP," Peddeti said. "Based on the results, our principal investigator was invited to give a talk at The Minerals, Metals, and Materials Society 2025 meeting, our program managers are happy, and I've received so much positive feedback that I am considering submitting a proposal for NEUP's Phase II Continuation CINR funding opportunity."



Chai Peddeti using a mechanical saw to fabricate surrogate fuel rods to test our FLAME CAMP system. Photo credit: AJ Gubser

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> “We want to fill gaps in the nuclear database as quickly, efficiently, and accurately as possible,” said Peddeti. “National laboratories can work on bigger things with more radiation, and we can test at the university level to contribute to these databases and ultimately help national labs in the nuclear field.”

Since FLAME-CAMP is coming to an end, the team has expanded this idea via the DOE-sponsored Integrated Research Projects program.

“Bridging the gap between experiments and modeling to improve the design of molten salt reactors,” Peddeti said.

Peddeti and the team further developed this idea to be applicable to melts and liquids, meaning they can perform isotope measurements on molten salts and liquid metals directly in situ and in service.

“This is a whole new ballgame,” Hosemann said. “Being able to directly quantify to parts per million and parts per billion precision what element and what isotope is in molten salts or liquid metals will have a tremendous impact in advanced reactor systems such as molten salt reactors. Coupled with in situ electrochemical measurements this new method helps to validate basic science concepts and enables operational controls for potential future reactors.”

Peddeti said this FLAME-CAMP project has been a great learning experience.

> “It is one of the most truly holistic projects in the sense of how it involves mechanical engineering, electrical engineering, nuclear engineering, and all that stuff,” he said. It’s really diversified my personal set of skills and I’ve learned so much on how to use various equipment.”

Hosemann said Peddeti’s ability to learn these skills has made him an asset to the field and a great mentor himself.

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“It takes a special team of students to bring such a complicated, innovative and novel concept to life and Peddeti’s abilities, good technical basics, broad understanding of the subject matter, strong work ethic and leadership skills made it possible to pull off this new innovation,” said Hosemann. “Peddeti learned how to lead by example. Sub-problems of this new concept were advanced by smaller teams of undergraduate, master’s and visiting students all facilitated by Peddeti. We at Berkeley pride ourselves to be excellent in the study on hand but also see beyond and keep the broader context in mind be it in science, education or the society as a whole. Peddeti has internalized this spirit.”

Peddeti and his team are making an impact in the nuclear industry, and he believes these accomplishments, along with those of others in the industry, are steppingstones for the world.

> “Clean energy is not just an America problem,” he said. “It’s a world problem. It’s humanity’s problem. We can create a group effort to create clean energy.”

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