Project Proposal for Ph.D.

Project Details	
Project Title	Development of a 3D-Printed Titanium-Zirconia material with improved longevity and biocompatibility for dental implant applications
Project Summary (Minimum 500 and maximum 2000 characters)	Dental implant failure is a common issue, primarily due to the challenge of developing a material that is compatible with human bone. Currently, titanium (Ti 6Al4V) and zirconia are widely used, but both come with limitations like modules of elasticity mismatch in case of titanium causes bone resorption, poor osseointegration and implant fracture due to overload. Titanium implants, while effective, present aesthetic concerns due to their greyish color, which can show through the gum tissue in patients with lighter mucosa, affecting their appearance. Over time, these implants are also prone to biocorrosion, especially in response to changes in pH and acidic substances in the oral environment. This corrosion, along with surface wear, leads to the release of titanium particles, which can accumulate in surrounding tissues and distant organs such as the lungs, kidneys, and liver. The erosion of the protective titanium oxide layer by bacteria further accelerates this process, raising concerns about potential systemic health effects. Additionally, titanium particles may affect cellular functions, including altering voltage-gated potassium channels in certain neurons. Whilst Zirconia, more favorable due to its ceramic nature, struggles to withstand high chewing forces, leading to crack formation. Previously, dental implants were fabricated using milling, a subtractive manufacturing process that resulted in significant material loss. A promising solution is the development of a hybrid material that combines the properties of both titanium and zirconia to overcome their individual limitations. This hybrid material, would be described as a ductile ceramic, can be fabricated using 3D printing technology i.e. powder blown technology or either fabricate a 3D printed titanium implants and thermal spray of zirconia over it. This approach not only minimizes material waste but also enables the creation of customized dental implants with enhanced compatibility with the bones, improving overall implant performance. This approach would improve the longevity of the implant and enhance patient safety during extended use. Additionally, modifications to the existing dental implant design are crucial to improve its performance. A better fixture design can help in preventing bacterial growth around the implant and minimize or eliminate bone loss caused by micro-movements of the teeth. Therefore, the present research proposal aims at developing a 3D-Printed Titanium-Zirconia material with improved longevity and biocompatibility for dental implant applications.

Ph.D. Supervisors				
Role	**Name of Faculty**		**Academic Unit in IITD/Institute/University**	**Email ID (Official)**
Supervisor 1	Prof.Pulak Mohan Pandey		Mechanical Eng. Dept. IIT Delhi	pmpandey@mech.iitd.ac.in +
Supervisor 2	Prof. Veena Jain		CDER, AIIMS Delhi	jainveena1@gmail.com +

Project requirements (Student qualifications, experience required, etc.) ***The candidate will be shortlisted based on common shortlisting criteria decided by ScRC (SIRe)**
• M.Tech. in Mechanical Engineering with manufacturing science background. • Should have knowledge of 3D Printing, finite element analysis, heat treatment, metallurgical and mechanical testing.

Source of fellowship/funding (CSIR/UGC/DBT/ICMR/ICAR/NEET-PG/DST-INSPIRE/IRD/FITT Project details, if any)
Institute Fellowship/ Project Fellowship

Role of Faculty Members involved:	
Supervisor-1	Providing guidance in the development and 3D printing of a ductile Titanium-Zirconia alloy, followed by the fabrication and optimization of a dental implant using Powder Blown Technology/ Directed Energy Deposition based 3D Printing process. Additionally, this includes conducting compressive testing and analyzing the phase transformations and microstructural evolution.
Supervisor-2	Providing expertise in assessing the biocompatibility of dental implants fabricated through 3D printing or other manufacturing techniques, ensuring they meet the necessary biological standards for safe integration with human tissue. This involves evaluating material selection, surface properties, and interaction with surrounding biological environments to optimize implant performance and longevity within the body.