# Ph.D. Course in Materials Science and Nanotechnology

University of Milano-Bicocca, Department of Materials Science, via Cozzi 55, 20125 Milano

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  **Building U9 – room U9/13**


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## Silicon nitride: A bioceramic with a gift


In the closing decades of the 20$^{th}$ century, silicon nitride ($Si_3N_4$) was extensively developed for high-temperature gas-turbine applications. Technologists attempted to take advantage of its superior thermal and mechanical properties to improve engine reliability and fuel economy. Yet, this promise was never realized in spite of the worldwide research, which was conducted at that time. Notwithstanding this disappointment, its use in medical applications in the early 21$^{st}$ century has been an unexpected gift. While retaining all of its engineered mechanical properties, it is now recognized for its peculiar surface chemistry. When immersed in an aqueous environment, the slow elution of silicon and nitrogen from its surface enhances healing of soft and osseous tissue, inhibits bacterial biofilm formation, and eradicates viruses. These benefits permit it to be used in a wide array of different disciplines inside and outside of the human body including orthopedics, dentistry, virology, agronomy, and environmental remediation. Given the global public health threat posed by mutating viruses and bacteria, silicon nitride offers a valid and straightforward alternative approach to fighting these pathogens. However, there is a conundrum behind these recent discoveries: How can this unique bioceramic be both friendly to mammalian cells while concurrently lysing invasive pathogens? This unparalleled characteristic can be explained by the pH-dependent kinetics of two ammonia species – $NH_4^+$ and $NH_3$ – both of which are leached from the wet $Si_3N_4$ surface.