# A new generation of transformational long implanted life dental implants

openaccessgovernment.org/article/a-new-generation-of-transformational-long-implanted-life-dental-implants/177747

4 June 2024

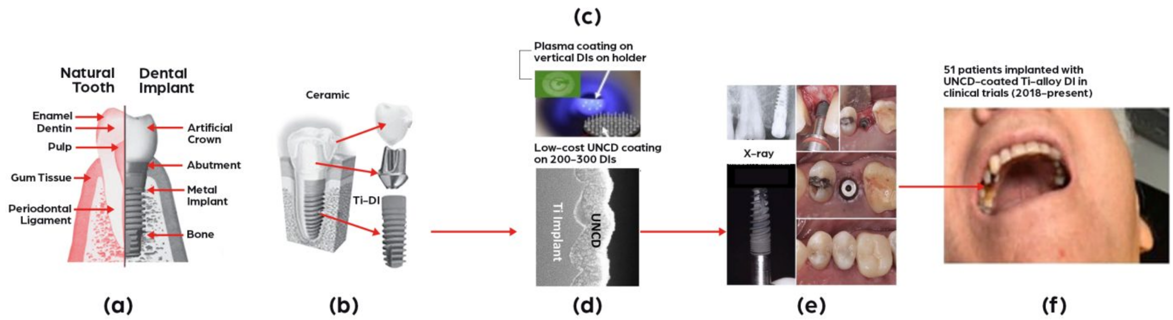


Figure 1. a) schematic of natural tooth and artificial DI; b) schematic of Ti-alloy DI; c) picture showing green plasma and array of vertical Ti-alloy DIs being coated (also shown is a schematic of industrial large array of DIs projected for low-cost fabrication of UNCDTM-coated DIs); d) cross-section SEM image of UNCDTM-coated Ti-alloy DI; e) X-ray and optical images of UNCD-coated DI in patient's mouth; f) picture of patient with implanted UNCDTM -coated DI, including test demonstrating excellent osseointegration.

## Unique low-cost/best biocompatible Ultrananocrystalline Diamond (UNCD™) coating enables a new generation of transformational long implanted life dental implants

This article summarizes the materials science/properties, integration strategies, and design/development of a new generation of dental implants (DIs) based on coating commercial Ti-alloy (Ti-6Al-4V) DIs with a unique transformational/low-cost/best biocompatible (because they are made of carbon atoms/element of life in human DNA/cells/molecules) ultrananocrystalline diamond (UNCD) coating.

Auciello developed/patented the Ultrananocrystalline Diamond (UNCD™) coating, which, with the help of collaborators, will improve the quality of life for people worldwide.

### Chemical/biological process destroying natural teeth

The American Dental Association (ADA) revealed that tooth decay is caused by acids and carbohydrates (sugars/starches) contained in food (milk, fruit, cookies, candies) left on teeth after eating, reacting chemically with bacteria in the mouth, producing acids, which destroy tooth enamel (hard tissue of tooth), causing caries on teeth, resulting in tooth destruction, requiring replacement by an artificial DI.

### A brief history of time

- In ancient China, 4,000 years ago, carved bamboo pegs were used to replace missing natural teeth.
- Egyptian remains (3,000 years old) showed copper metallic pieces replacing natural teeth.
- About 2,000 years ago, human teeth were replaced with animal ones.
- In 1931, archaeologists discovered a Mayan woman's remains from 630 AD. The remains showed natural teeth replaced by pieces of seashell, maxillary bone growth around the implants, and osseointegration.

In the 1960s, Swedish scientists introduced a camera with an external titanium (Ti) cover in the tibia of a rabbit to observe circulatory/cellular changes in living tissue. When removing the camera, they found rabbits' bone adhered to the titanium metal surface, demonstrating Ti's potential good integration with human bones. It provided a material for different prostheses implantable in human bones, including DIs. The bone/metal integration phenomenon was named osseointegration, and it was initially extensively investigated for DIs. [(1)]

Materials extensively used for dental implants and other prostheses Titanium (Ti) or Ti alloys (mainly Ti-6Al-4V) are currently widely used in different prostheses to replace degraded/ destroyed natural human body parts (teeth (see Figures 1 (a) and (b)), hips, knees, and other joints). Ti/Ti-alloys are used because R&D demonstrated that they are biocompatible and would resist the chemical/mechanical environment of the human body.

However, in recent years, the industrial/ medical communities observed that metal prostheses undergo many types of failure, mainly due to substantial chemical/mechanical effect in the human body. Extensive literature revealed the failure of metal-based DIs due to the chemical/mechanical environment in the mouth, see for example. [(2,3)]

A key overlooked materials science issue was that any Ti or Ti-alloy develops a TiO2 layer upon exposure to the atmospheric environment. Auciello et al. demonstrated that oral fluids chemically attack the TiO2 layer, releasing TiO2 particles, which kill human cells upon reacting with mouth tissue. The chemical attack of the TiO2 layer on Ti-alloy DIs' surface results in ~15% failure of current commercial DIs worldwide in the first four to five years after implantation, requiring replacement, with extra patients' discomfort and cost.

## Materials science/development of new DI technology based on transformational UNCD™ coating

Revolutionary UNCD™ coating exhibits excellent resistance to chemical corrosion by any strong acid and body fluids, enabling efficient growth and migration of embryonic stem, bone, and neural cells on the surface of the coating, as demonstrated in pioneering work by Auciello's group. (4) UNCD™ coatings are grown on Ti-6Al-4V DIs using microwave plasma chemical vapor deposition (MPCVD).

The MPCVD process involves using a novel patented Ar-rich/$CH_4$ gas mixture flown into an air-evacuated chamber, producing polycrystalline diamond films with the smallest grain size demonstrated today [3-5 nm] (see Figures 1 (c) and (d)). $CH_4$ molecules cracked by the plasma produce $C_2$ dimers and $CH_x$ [x=1, 2, 3] radicals, which react chemically and nucleate and grow UNCD™ coating on any material's surface.

The UNCD™ coating exhibits unique combinations or properties: hardness [98 GPa] and Young's modulus [1,000 GPa] like diamond gems, lowest friction coefficient [0.02-0.04] compared with metals [≥ 0.5] currently used in industrial products and prostheses [DIs, hips, knees].

Arrays of Ti-alloy DIs were positioned vertically oriented, as shown in Fig. 1 (c) and coated simultaneously with UNCD™films at a low cost.

Clinical trials since 2018 implanting UNCD™-coated commercial Ti-6Al-4V DIs in 51 patients (see Figures 1 (e) and (f) and biological and oral fluids-DI tests demonstrated that the UNCD™-coated DI will provide the next generation of DIs with orders of magnitude superior performance than current commercial Ti-alloy DIs.

**References**


1. G. Brånemark et al. (Eds.), Introduction to osseointegration tissue:-integrated prostheses- osseointegration in clinical dentistry. Quintessence Publishing, Chicago, 11, 1985.
2. D.G. Olmedo et al., Biological response of tissues with macrophagic activity to titanium dioxide, J. Biomed. Mater. Res., Part A, 84(4), 1087, 2008.
3. D.C Rodriguez, et al., Titanium corrosion mechanism in the oral environment: A retrieval study, Materials, 6, 5258 (2013).
4. K. Kang, O. Auciello, D.G. Olmedo, D.R. Tasat, G. López-Chávez, Science and Technology of Ultrananocrystalline Diamond (UNCD™) Coatings for New Generation of Implantable Prostheses: Dental Implants, Artificial Hips and Knees, Ch 5., in book Ultrananocrystalline Diamond Coatings for New Generation High-Tech and Medical Devices, 141-174, O. Auciello (Ed.), Cambridge Publisher, 2022.



- Orlando Auciello
- Distinguished Endowed Chair Professor, University of Texas at Dallas (UTD,
- Materials Science and Bioengineering Departments, Richardson, Texas, U.S.Co-Founder CEO, Original Biomedical Implants (OBI-USA), Richardson, Texas, U.S.
- Co-Founder/CEO, Original Biomedical Implants (OBI-México), Hermosillo, Sonora, México
- Co-Founder/Equity Holder/Investor, Advanced Diamond Technologies (Sold-2019), Romeoville, Illinois, U.S.
- Collaborators: K. Kang (UTD/BMEN/USA/2015-17); D.G. Olmedo (Universidad de Buenos Aires-Argentina); D.R. Tasat (Universidad de San Martin-Argentina); G. López Chávez (Bioingeniería Humana Avanzada-México).


Please Note: This is a Commercial Profile