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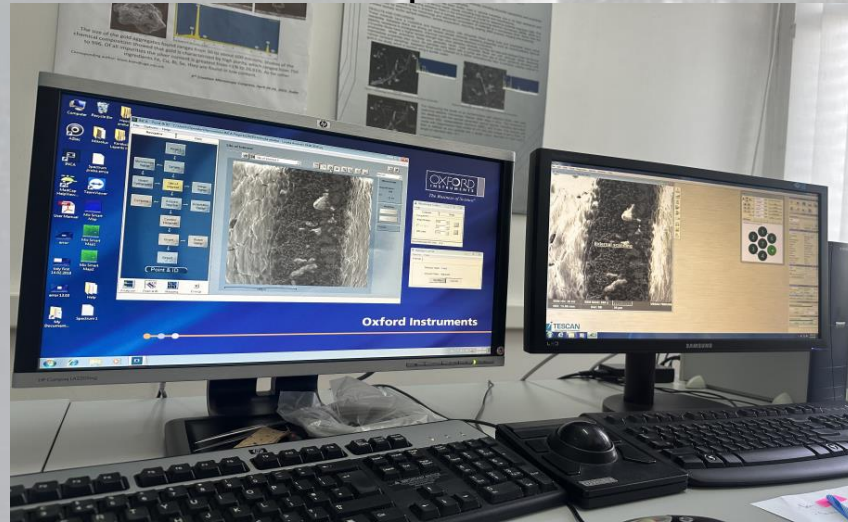


# Dental implants analysis with SEM microscope

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# Scanning Electron Microscope (SEM)

- A **Scanning Electron Microscope (SEM)** is a high-resolution imaging tool that generates detailed images by scanning a specimen's surface with a concentrated beam of electrons. These electrons interact with the atoms of the sample, producing signals that reveal information about its surface morphology and elemental composition. The beam follows a raster scanning pattern, and image formation relies on correlating beam position with signal intensity. In standard operating mode, the SEM captures secondary electrons (SE) emitted from the sample surface, typically detected using an Everhart–Thornley detector. The quantity of secondary electrons—and therefore the signal intensity—is influenced by the surface topography of the sample. Advanced SEM systems can achieve spatial resolutions below 1 nanometer. Depending on the instrument setup, samples may be analyzed under high vacuum (conventional SEM), low vacuum, or even under environmental conditions (ESEM), and across a broad temperature range—from cryogenic to elevated temperatures.



# Scanning Electron Microscope (SEM)

The **Electron Microscopy Laboratory** specializes in analyzing the morphology and chemical composition of various materials under controlled vacuum environments. Imaging can be performed using both **SE and BSE (Backscattered Electron)** detectors. When samples are properly prepared, imaging resolutions better than 5 nm can be attained. Elemental analysis is conducted with an **EDS (Energy Dispersive Spectroscopy)** detector, capable of detecting elements ranging from beryllium (Be) to plutonium (Pu), with an energy resolution of up to 125 eV.

This technique enables both qualitative and quantitative chemical characterization of the specimen.



# MATERIALS AND METHOD

- The Scanning Electron Microscopy (SEM) technique finds broad application across numerous disciplines, including mineralogy, petrology, crystallography, paleontology, mining, electronics, industrial glass and ceramics, heritage preservation, metallurgy, mechanical and civil engineering, dentistry, pharmacy, medicine, and biology.
- Sample Preparation for SEM in Dentistry
- In dental research, the preparation of samples for SEM analysis requires precise protocols tailored to the specific focus of the investigation. The standard preparation procedure includes:
  1. **Drying:** Most samples must be completely air-dried at room temperature to eliminate residual moisture.
  2. **Mounting:** The sample is affixed to a specimen stub using a double-sided carbon adhesive tape.
  3. **Coating (if necessary):** Depending on conductivity requirements, the sample may be sputter-coated with carbon or gold.
  4. **Imaging:** The sample is then placed into the microscope chamber and is ready for scanning (Figure 1).

# The microscope chamber



Chamber View

# Implant Surface Analysis Procedure

## 1. *Surface Cleaning and Preparation*

- The implant surfaces are carefully cleaned to ensure accurate and contamination-free analysis.
- A pristine surface is essential for reliable identification of both intrinsic material properties and any surface contaminants.

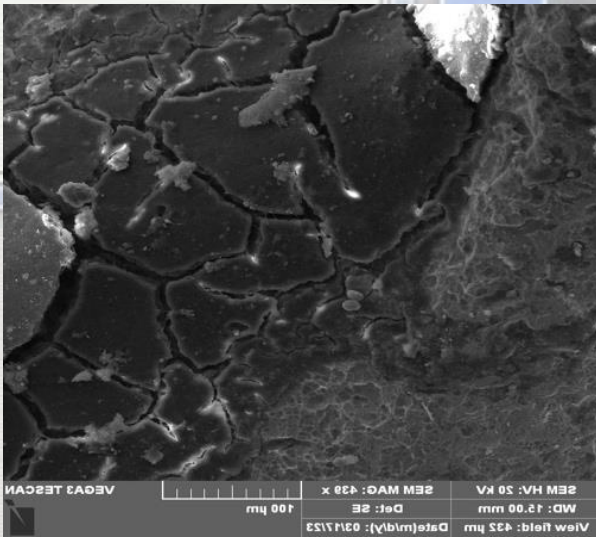
## 2. *SEM Imaging and Elemental Analysis*

- **Microstructural Evaluation:** SEM provides high-resolution visualization of the implant surface, facilitating micro- and nanostructural analysis.
- **Contamination Mapping:** SEM imaging can reveal surface residues such as dust, oil films, or oxidation products.
- **EDS Spectroscopy:** Coupled with SEM, EDS enables detailed qualitative and quantitative analysis of elemental composition. It is particularly effective in detecting surface contaminants and determining their elemental identity and concentration.

# Implant Surface Analysis Procedure

## 3. *Detection of Surface Contaminants*

- **Metallic and Non-metallic Residues:** SEM/EDS analysis can detect trace amounts of potentially harmful elements, such as aluminum, chlorine, sulfur, or iron—residues that may be introduced during manufacturing and can lead to peri-implantitis or implant degradation (Figure 2).
- **Oxidative Layers and Organic Films:** The presence of oxide layers or organic residues (e.g., from lubricants or cleaning agents) can compromise osseointegration and destabilize the implant.



**Figure 2. SEM Analysis of a Dental Implant**

# SEM Analysis of a Dental Implant

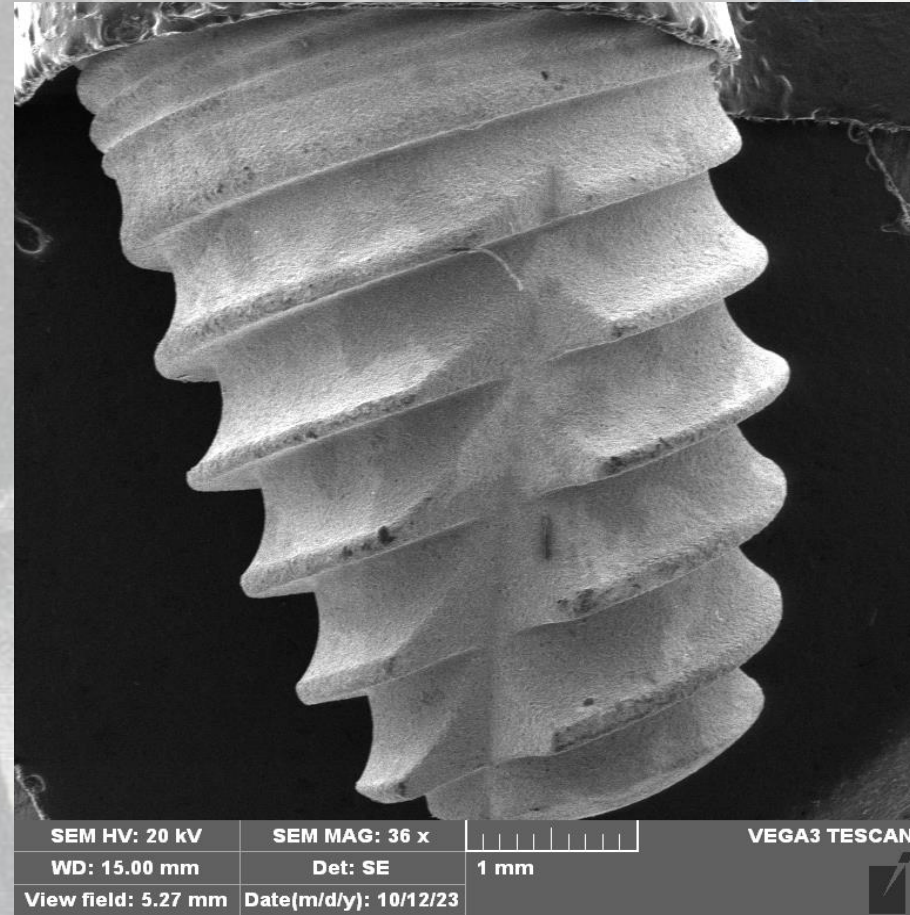
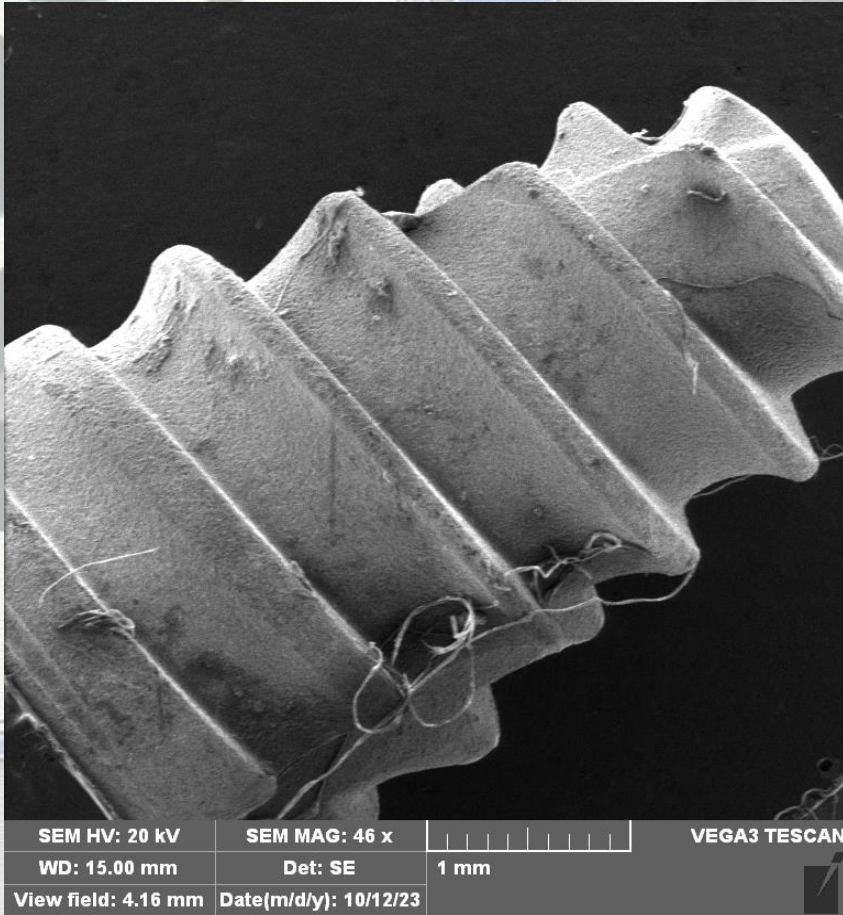
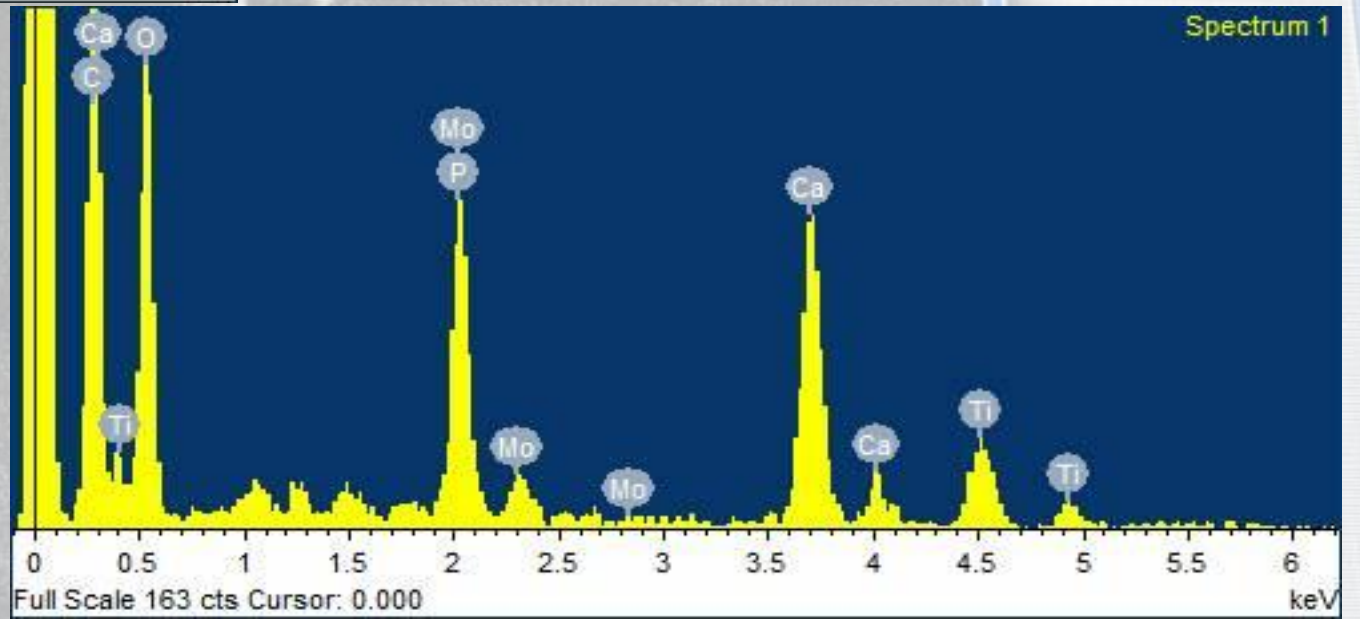
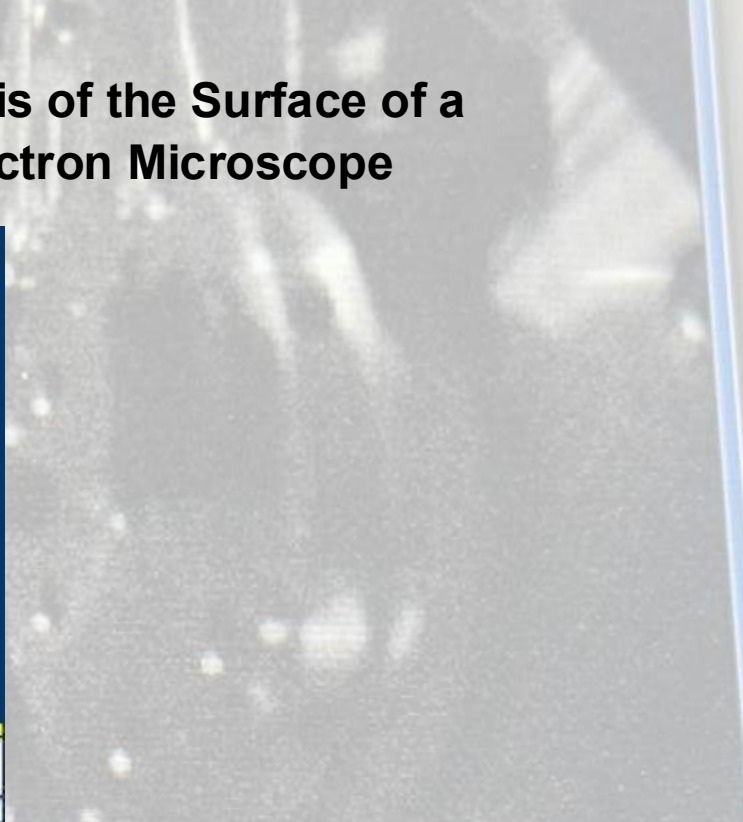
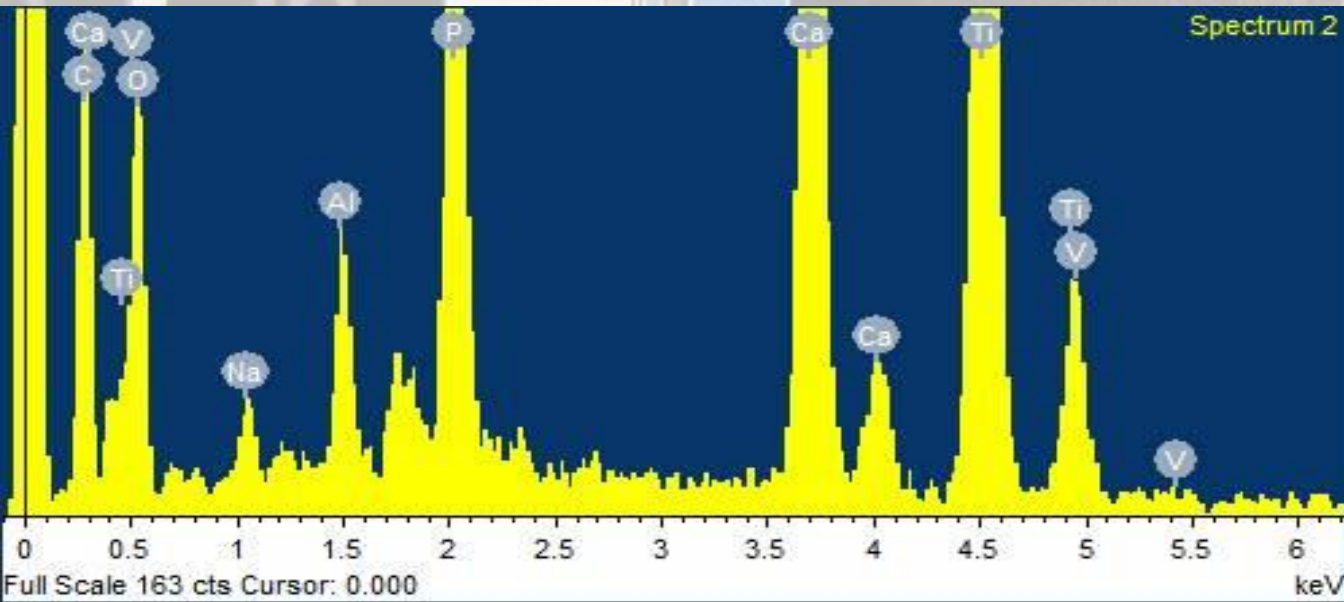
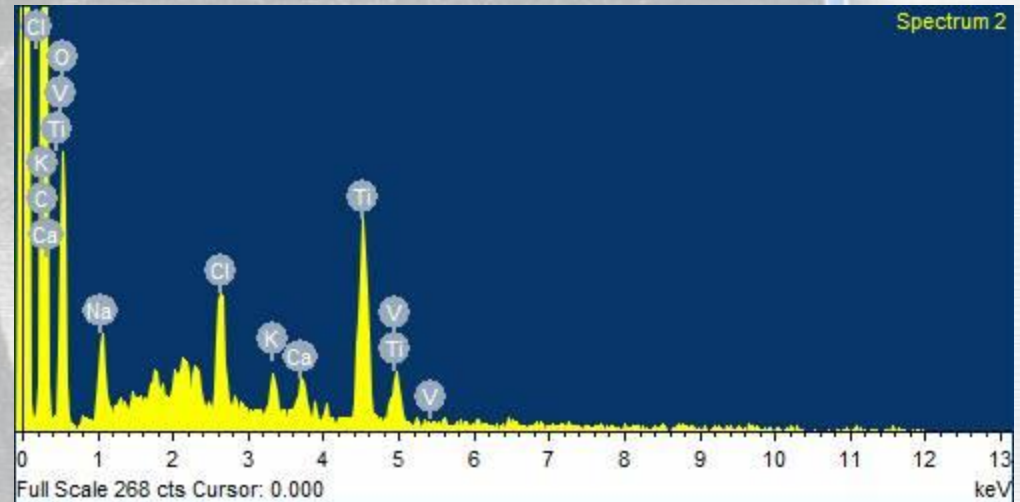
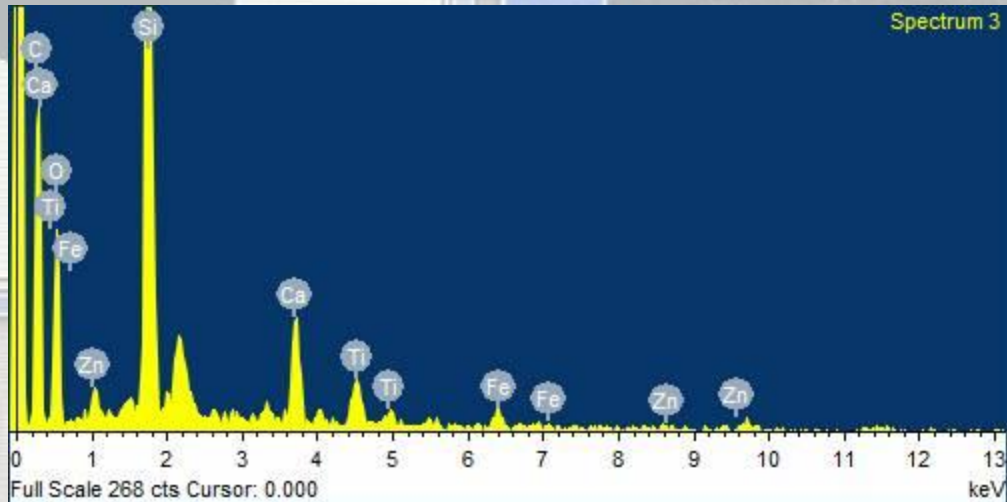
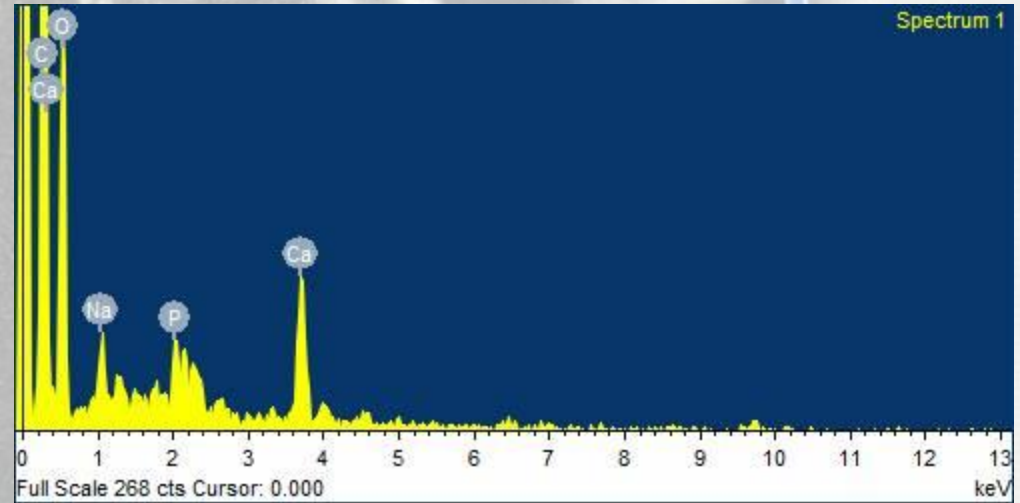
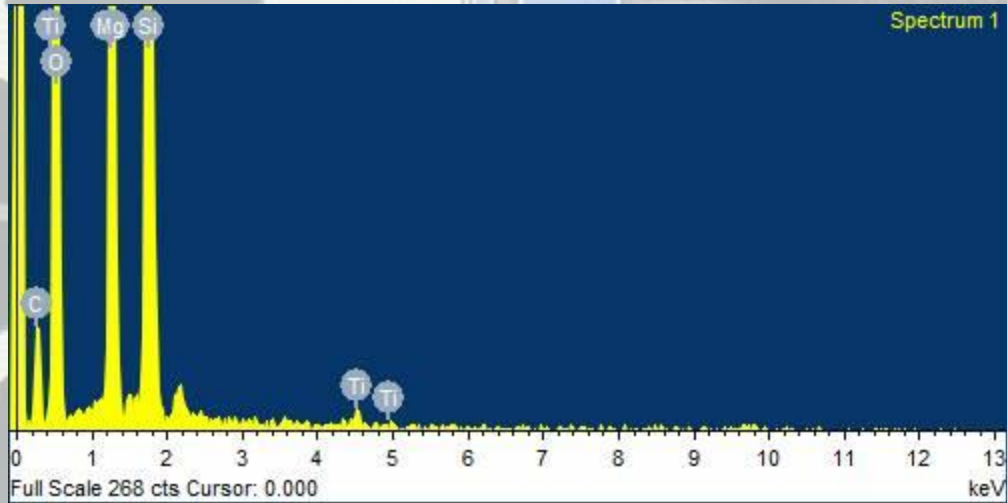


Figure 3a, 3b. Chemical Analysis of the Surface of a Dental Implant Using an Electron Microscope



amber View

# Chemical analysis with SEM microscope



# CONCLUSION

**Elemental Surface Analysis:** Data obtained from **Scanning Electron Microscopy (SEM)** and **Energy-Dispersive X-ray Spectroscopy (EDS)** offer precise identification of the chemical elements present on the implant surface. This enables detection of foreign elements that are not part of the implant's original material composition, potentially introduced during the manufacturing process or surgical placement (Figures 3a and 3b). **Micro- and Nanoscale Topographical Visualization:** High-resolution SEM imaging provides detailed insights into the surface morphology of the implant, including assessments of porosity and surface smoothness—key parameters for optimal osseointegration. The presence of irregularities or contaminants in the surface structure may signal an increased risk of implant failure or poor biological integration. The **elemental composition of dental implant surfaces** exhibited variation across different samples, largely influenced by the implant class and manufacturing process. Through our **SEM/EDS-based investigation**, the primary goal was to identify and quantify surface contaminants, assessing the proportion of each detected element and evaluating their potential impact on the biological process of **osseointegration**.

**Thank you for your attention!**

