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Zwischgold – The Secret Nanomaterial of Medieval Gilding

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Zwischgold is a bi-layer metal leaf made from a thin gold layer atop a silver base. Since it uses less gold to present an actual gold surface than simple gold leaf, its application was popular on medieval sculptures and altarpieces, and was strictly regulated by guilds. However, information about the materials and production of medieval Zwischgold is scarce. In addition, the chemical instability of the silver component has been an obstinate problem for the conservation of Zwischgold artefacts. Difficulties in identifying well-preserved examples^[1] and the need for nanoscale measurements^[2] have also hindered modern research of Zwischgold.

We used an advanced imaging technique, Ptychographic X-ray computed tomography (PXCT), to measure nanoscale, quantitative 3D images of a Zwischgold micro-sample taken from the central figure *Mary* of the 1420-dated Leiggern Altar, which is on permanent exhibition in the Swiss National Museum, Zurich. The PXCT measurements clearly demonstrate a decreasing density (increasing porosity) of the leaf materials and the development of corrosion products within this 800-year-old sample. The voids at the underside of the metal leaf that reach over 50% of the total leaf area indicate a delamination tendency of the leaf from its substrate, which may be a critical issue for the future conservation of Zwischgold-applied artefacts.^[3]

The PXCT measurements show that the *Mary* sample has an average gold layer of *ca.* 127 nm and full leaf thickness of *ca.* 252 nm, which stand at the higher end of the thickness range observed in our previous SEM measurements of 74 medieval samples.^[2] The nanoscale thickness range (*ca.* 20–50 nm) of the gold layer of medieval Zwischgold strongly supports its competitive market price compared to gold leaf (*ca.* 160 nm thick on average^[4]).

The revelation of nanomaterials in Zwischgold demonstrates that the Middle Ages was not the Dark Ages but rather a climax epoch that produced exquisite art technologies.

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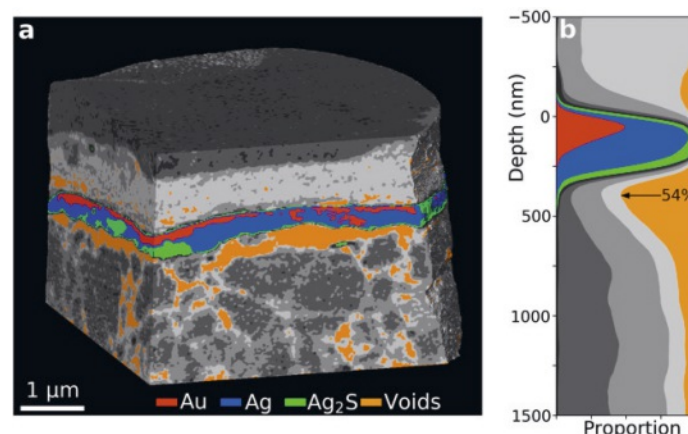
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als. The PXCT measurements were performed at the cSAXS beamline of the Swiss Light Source at the Paul Scherrer Institute.



The central altar figure *Mary* (Inv. No. LM16701.2) in the Leiggern Altar (Inv. No. LM16701.1), 1420, Swiss National Museum. The sample-taking position is indicated by a green arrow. Reproduced from Wu *et al.*^[3] Copyright: Schweizerisches Nationalmuseum, (source: Inv. No. LM16701.1, DIG-2195).

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(a) Segmented PXCT 3D image of the *Mary* sample showing the locations of Au (red), Ag (blue), silver corrosion products (green), voids (orange), and other segments in shades of grey. (b) Stack plot of the depth profile of the sample, aligned to the Au segment. Reproduced from Wu *et al.*^[3]

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