High Resolution Mapping of DCIS Breast Microcalcifications

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Ductal Carcinoma In Situ

> Ductal carcinoma in-situ (DCIS) is a pathological breast disease with the potential to form invasive breast cancer.
> DCIS is usually diagnosed using breast screening mammography by the presence of calcium deposits (microcalcifications).

Microcalcifications

> Microcalcifications in pathological breast tissue are made of calcium phosphate (hydroxyapatite).
> How and why calcifications form is unknown.
> Hydroxyapatite is a nanocrystalline material, which can be examined using X-ray diffraction.

X-Ray Diffraction

Incident X-rays (λ)

Sample

Scattered X-rays

Detected

Transmitted X-rays

Fig. 1: X-ray diffraction in transmission was carried out with a 10 keV beam of spot size 5 x 5 μm, using steps of 25 μm. (top) Crystallite size (L) and non-uniform strain (ε) can be calculated from peak broadening (β) and position (θ) of the 002 and 004 peaks (circled) using the Williamson-Hall equation (right & below).

βcosθ = 4εsinθ + 0.9λ

Hydroxyapatite Heterogeneity

Fig. 3: Diffractograms of the centre and edges of the same calcification.

> Hydroxyapatite crystallites are larger and more strained towards the centre of the calcification.
> Central crystallites are more mature than peripheral ones, suggesting they were formed earlier.

An additional phase

> Whitlockite is an additional phase found in microcalcifications.
> Whitlockite is present heterogeneously, and found at higher levels in central regions.

Fig. 2: Map of HAp:whitlockite ratio across a single DCIS calcification. White space indicates no whitlockite present.

Fig. 4: Maps of crystallite size (left) and non-uniform strain (right) across a single DCIS calcification.

Conclusion

> DCIS microcalcifications show high levels of nanostructure heterogeneity.
> Calcifications are not exclusively composed of hydroxyapatite.
> High resolution maps may provide an insight into how microcalcifications form in pathological breast tissue.

References