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Low-temperature thick-film dielectrics stabilised by reaction with a nanocrystalline powder

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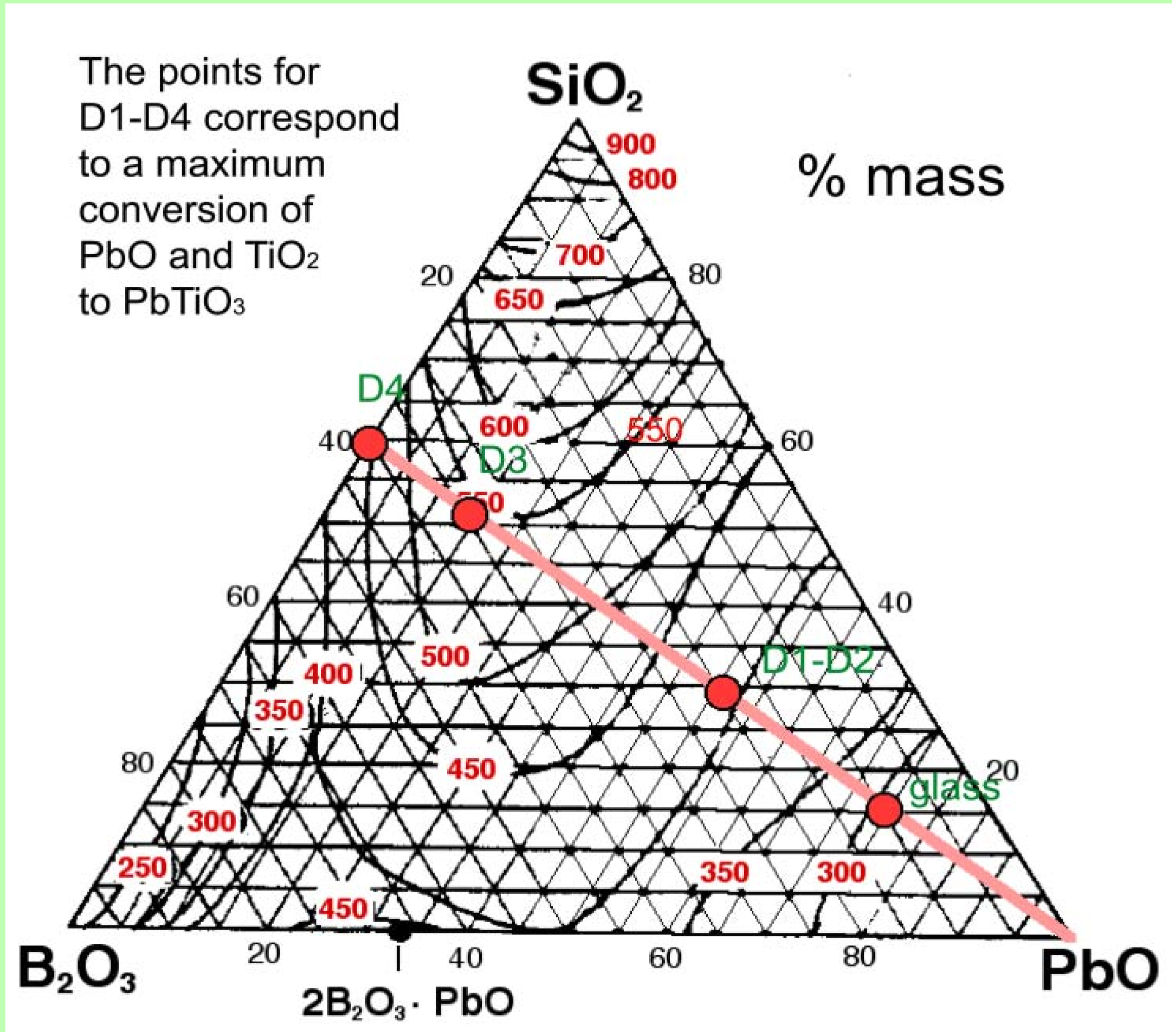
Aim of this project: to develop dielectrics for a low-temperature thick-film system for substrates such as steel, titanium, aluminum and glass.

Stabilisation of a glass by controlled reaction with a nanograin powder :

PbO (glass) + TiO_2 (nano grains) ⟹ $PbTiO_3$

Stabilisation by **Pb depletion in glass** and **increase in filler volume**

Pb depletion in glass



Depletion of PbO results in an increase of stability.

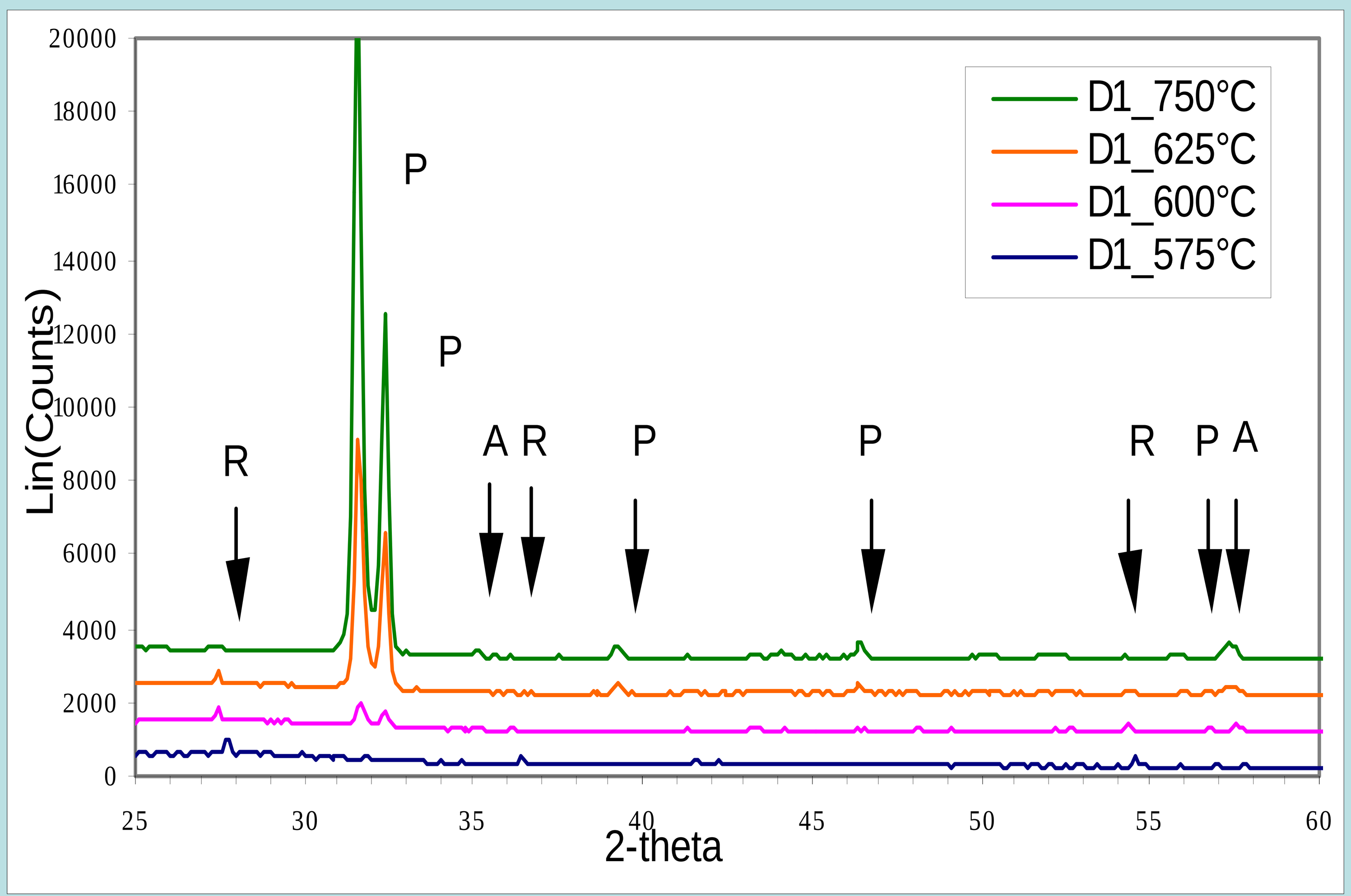
(Diagram after Trubnikov, 2000)

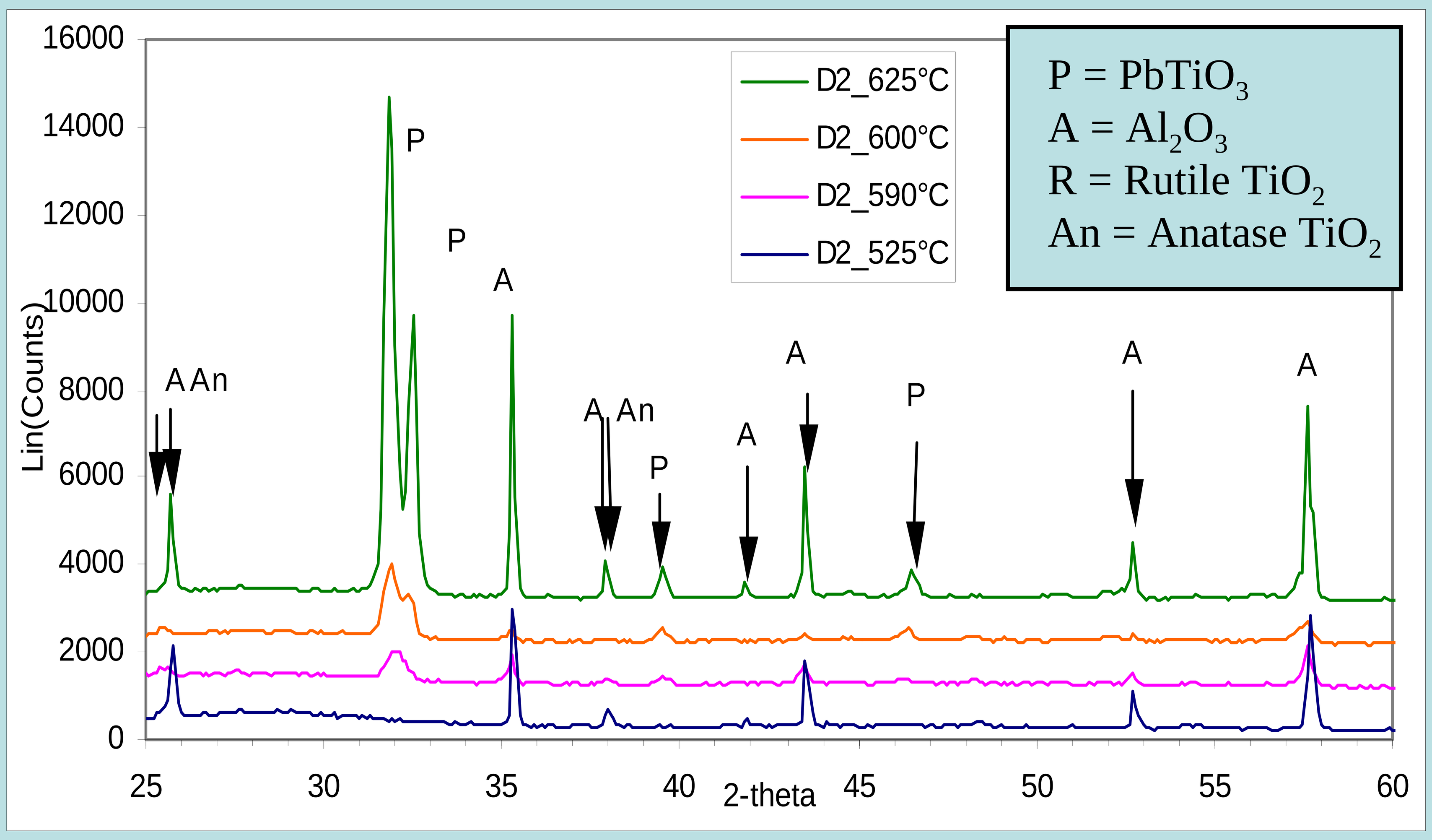
Preparation of pastes: TiO_2 powder have been mixed with glass with different proportions. Two TiO_2 powders with different grain diameter have been used. The powder with coarse grains contain only rutile, stable phase of TiO_2.

On the contrary the powder with finer grains contains anatase which turn into rutile at high temperature.

	TiO_2 grain diameter	Fraction Ti/Pb
D1	5 µm	0.63
D2	21nm	0.63
D3	21nm	0.95
D4	21nm	1.33

X-ray Spectra of D1 and D2 pastes fired at different temperatures





X-ray characterisation allows to examine at which temperature $PbTiO_3$ peaks appear and rutile and anatase peaks disappear. The crystallisation takes place 20°C lower with the nanograin TiO_2 powder (D2) than with the coarse-grained one (D1).

Conversion level of TiO_2 to $PbTiO_3$

100% of the TiO_2 has reacted with the PbO contained in glass for D1 and D2 pastes, in accordance with the stoechiometry. For D3, only 70% of $PbTiO_3$ has been mesured (instead of 100%), due to kinetic limitations. 50-60% of $PbTiO_3$ has been obtained with D4, which contains more TiO_2 than PbO. Moreover, the figure 1 confirms that the crystallisation takes place 20°C lower with D2 than D1.

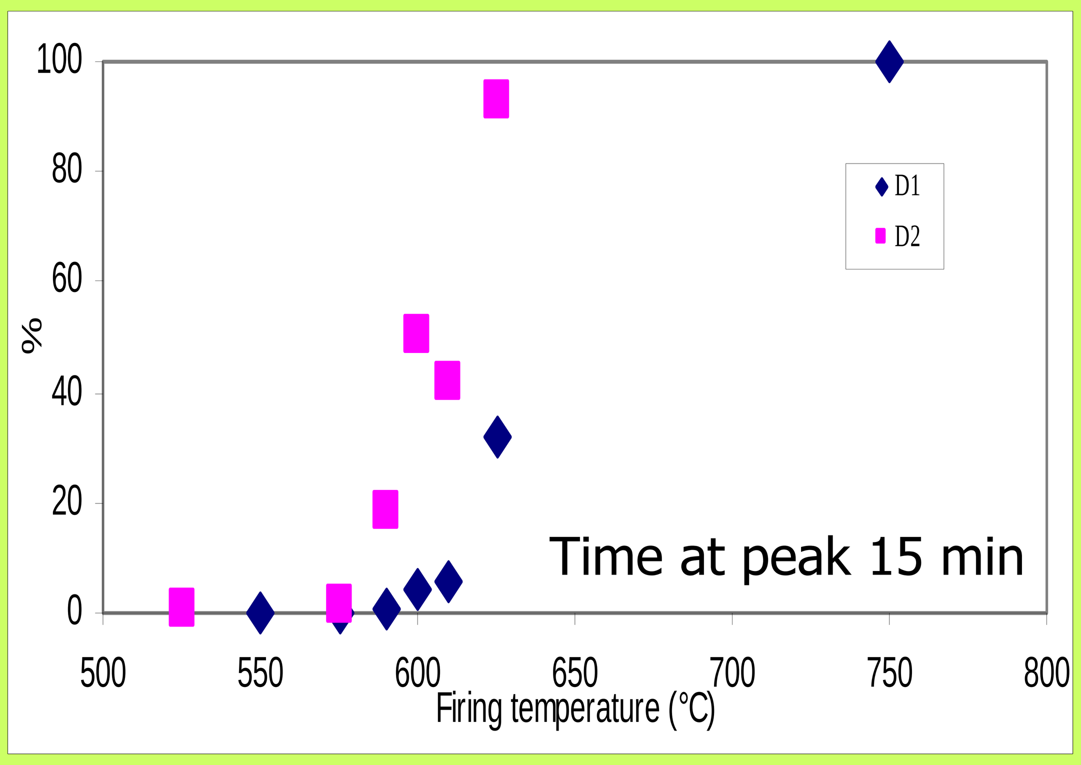


Figure 1

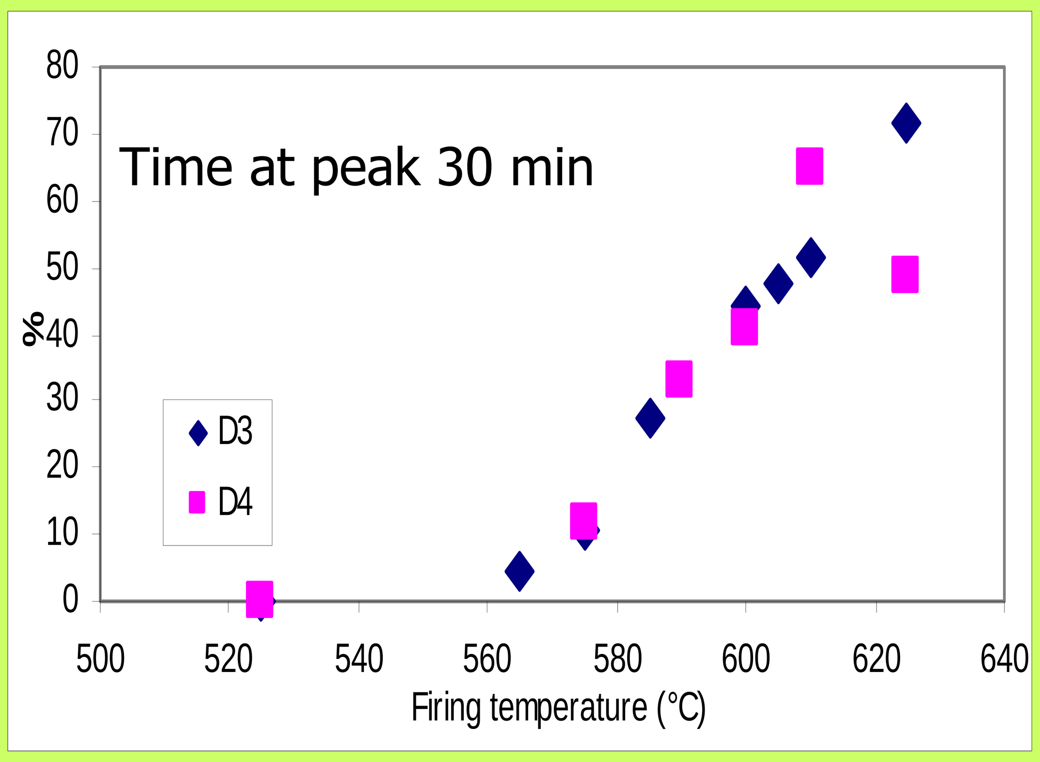


Figure 2