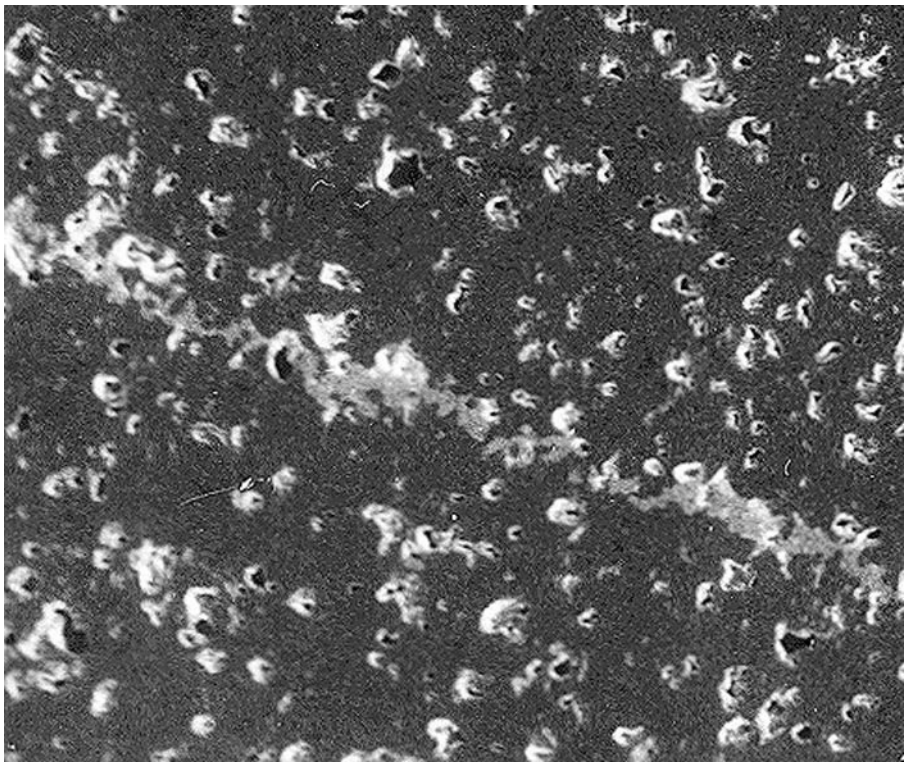
CAPACITOR DEVELOPMENT

THE WORK OF THE STL CAPACITOR GROUP CAN BE DIVIDED INTO THREE MAIN ACTIVITIES

1. Development of new materials and processes for making multilayer ceramic capacitors based on barium titanate-zirconate. The lead for this work was **John Alexande**r, and the process for making the multilayer structure of alternate dielectric and metallization was to screen print the materials dispersed in a paste (cf thick film printing). The work was in support of ITT Paignton and Yarmouth. John's work was so successful that he was headhunted to join a capacitor manufacturer in the USA.
2. Development of tantalum capacitor materials by **Ernie Workman, Denis Hazledon** and **Eric Bush.** In order to reduce the production costs for solid tantalum capacitors, the manufacturers of the expensive tantalum powder raw material were developing finer and finer sub-micron powders to yield a higher specific capacitance/g of tantalum.

   The STL approach was to reduce the tantalum content of the powder by coating alumina powder with a thin layer of tantalum, the so-called TCP process. The problem was that the vapour deposition process utilising hydrogen reduction of tantalum pentachloride did not produce a uniform layer of tantalum on the alumina particles. The tantalum deposited in the form of 'micro-islands' on the alumina powder surface.



After considerable trials, one day, by pure accident, a trace of nitrogen contaminated the high temperature deposition process and it was found that

uniform nucleation of the tantalum coating had been completely achieved. Subsequently it was found the if a mixture of alumina powder plus a small quantity of tantalum powder plus a small quantity of ammonium chloride was placed in an evacuated glass tube and heated to around 500°C, the alumina powder was coated with a uniform layer of tantalum nitride which could the be subsequently coated with tantalum.

Ref	Resistivity Ohm cm	Wt% Ta	Anodising voltage	Capacitance yield µC/g	µC/gcc	Comments
MP10	700k	51.3	-	-	-	3µ alumina Ta deposition ex nucleation process. Powder difficult to compact Into capacitors. 13µm alumina, Ta depn without nucleation MP7 only nucleated, no Ta depn 3µm alumina, Ta deposition after nucleation.
MP16	1.3M	63.2	-	-	-	
MP21	490	76.5	-	-	-	
MP7	2.3	52.7		7000	38000	
MP2	0.4	38		8300		
NT36		52.7	12	14300	58000	
LR118	0.1	64.1	24	14200	57700	
LR119	0.4	53.1	24	**20400**	**71700**	
MP25	0.1	58	24	19600	80300	
NT55[1]	>10M	40	-	-	-	Physical mixture of 40% Ta & 60% alumina by weight, with nucleation process only.
NT55[2]	0.3	40	12	10000	30000	

1. Before nucleation 2. After nucleation

A patent was submitted but later abandoned, and it is worth noting that variations on this method of nucleation are currently utilised in thin layer deposition processes.

3. Reliability studies of multi-layer ceramic capacitors, with **Miles Drake**, **Rab Chittick** and **Sadie Hughes** investigating the short-circuit life-test failures of multi-layer capacitors. It was standard practice to clean the capacitor chips prior to measuring their insulation resistance using acetone. However, one day, by chance, **Rab** used methanol as the solvent and noticed that in one batch of capacitors, prepared for subsequent life testing, there was a relatively large number of insulation resistance failures. When samples from the same batch were washed in acetone NO FAILURES were observed.

   Further microscopic investigation of the failures indicated there were micro-fissures within the multilayer structure. Following life testing of the capacitor batch indicated an abnormally high failure rate.

   A patent application was submitted for the 'Methanol Test' but was later abandoned.

Eric Bush September 2014