ADHESION, PHASE MORPHOLOGY, AND BONDABILITY OF REACTIVELY-BONDED AND FRIT-BONDED GOLD AND SILVER THICK-FILM CONDUCTORS

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The phase morphologies of reactively-bonded commercial gold and similarly bonded silver thick-film conductors have been characterized as a function of firing conditions and material types. Adhesion strengths of the samples were measured by a solderless technique, and the strengths are correlated in this presentation with the development of phase morphologies in the film and with the adhesion data of other investigators. The bondability-adhesion strength trade-off for frit-bonded and reactively-bonded conductors is discussed in view of an analysis for potential bondability which was made using a recently developed technique. First-order theories of adhesion development in reactively-bonded and frit-bonded conductors are briefly discussed, and conclusions are drawn for optimizing firing parameters in the processing of frit-bonded and reactively-bonded thick film conductors.

Key words: thick-film gold, thick-film silver, adhesion, reactively-bonded, frit-bonded, mercury leaching.
**Introduction**

Although reactively-bonded materials which can be air-fired below 1100°C are not entirely new,\(^1\),\(^2\),\(^3\) such thick-film conductor materials have recently received considerable attention.\(^4\),\(^5\) In the last few years, the increased capabilities of thick-film processes, together with the commercial availability of beam-lead devices, have begun to make obvious certain limitations of more conventional thick-film conductors. Reactively-bonded thick-film conductors have interesting potential for overcoming some of these limitations.

The work reported here is directed to understanding this new class of conductor materials in the context of current knowledge of conventional thick-film (frit-bonded) conductors. Our study of reactively-bonded thick-film conductors is still underway; however, the high interest in such materials prompted a presentation now. A few definitions may help to prevent confusion over certain terms used in this paper.*

**Thick film** - a film deposited by screening, stenciling, or doctor blading a semi-liquid paste through a mask onto a substrate. The film-substrate layer structure is rendered useful by firing, usually at temperatures between 500°C and 1100°C.

**Frit-bonded** - made adherent (to the substrate) by including in the paste, particles of glass, bismuth oxide and/or other fluxing agents which become somewhat fluid on firing and wet the substrate and the sintering metal.

**Reactively-bonded** - made adherent principally through the presence of discrete chemical compounds which are formed during firing at the film-to-substrate interface, from components of both the thick-film ink and the substrate.

* The term "fritless" is being used ambiguously to describe both inks containing no bonding agent and in place of the term "reactively-bonded". The use of "fritless" has been purposely omitted in this paper.