

CERAMIC AND COLLOIDAL PROCESSING - EXERCISES

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2021**

Exercises 14 – Solutions

1. How de-sintering or swelling can be detected? Why does it happen?

Solution

Swelling can be identified following the sample shrinkage upon sintering, for instance by TMA or dilatometry. It might be due to unwanted liquid phase due to solubility of the solid phase into the liquid phase at high temperature. Transient liquid phases can be also formed at high temperature due to some chemical inhomogeneity or limited stoichiometry mismatch.

2. Which instrument can be applied to identify an appropriate sintering strategy?

Solution

Any method that allows monitoring the shrinkage vs. time, e.g. TMA or dilatometry. A strategy is to develop a master sintering curve (MSC), which can be obtained elaborating sintering experimental data collected at different heating rate.

3. Which material properties are of major relevance in case co-firing of different ceramics?

Solution

Co-firing is a very demanding task. Once chemical compatibility among material is given (that is materials in contact to each other are able to maintain their own properties or evolve in a controlled manner) several thermo-mechanical parameters need to be considered, such as sintering onset, overall shrinkage, shrinkage rate, thermal expansion and eventually phase transitions.

4. Describe which forces are involved in the dip and spin coating deposition

Solution

In the case of dip coating viscous force balances the gravitational force during the coating, therefore the substrate speed has an influence on the deposition thickness. In spin coating, viscous force is balanced by centrifugal force; therefore, the rotation speed has an influence on film thickness.

5. Describe the main differences between chemical and physical vapour deposition

Solution

Among many differences:

- PVD uses of a target of the material to deposit, the deposition is strongly directional, operate in vacuum and RT, and the composition of the deposited material corresponds to that of the target;
- CVD uses a volatile precursor of phase to deposit that reacts in gas phase or directly on the substrate, it can operate in atmospheric conditions but at relatively high temperature. The deposition is not directional.

6. Which material properties are of major relevance in case of metal-ceramic joining?

Solution

Metal and ceramics have different thermal expansion coefficients and ceramic-metal adhesion might be critical even at room temperature. Usually, intermediate layer(s) of materials with intermediate properties are needed to achieve reliable coatings.

7. Provide an example of ceramic coating and a suitable method to realize it.

Solution

Several examples are provided in the slides. For instance, thick coatings can be obtained by thermal spray as for calcium phosphate coating for biomedical devices or zirconia coating for turbine blades. Thinner coating can be obtained by spin or dip coating for anti-fog, anti-scratch treatment or electronic devices such as gas sensors.