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Predicting the Final Shape of Free Air Ball (FAB) in Semiconductor Package Wire Bonding

Jefferson S. Talledo
New Product Development and Introduction, Back-End Manufacturing & Technology, STMicroelectronics, Inc.
Calamba City, Laguna, Philippines 4027

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I. Overview

- Wire bonding is a very popular method of interconnection used in semiconductor packages.
- The wire (e.g. gold, copper, silver) provides electrical connection between the integrated circuit (IC) die to the package lead or terminal as shown in Fig. 1.
- A bonding capillary of wire bonding machine is used to bond the electrically-conductive wire to the IC die bond pad by forming a free air ball (FAB) first at high temperature before the bonding.

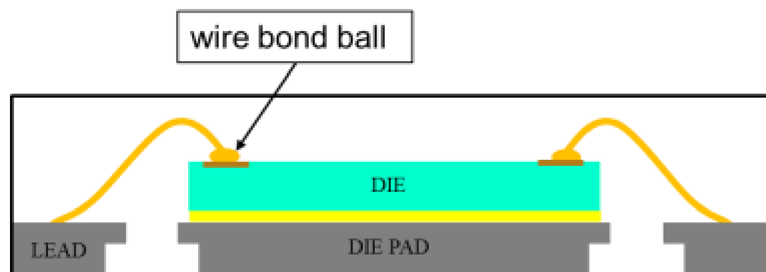

Fig. 1. Semiconductor package with wire bonding connection from integrated circuit (IC) die to package lead/terminal.

II. Problem Identification

- There is a need to be able to predict the final shape of the free air ball after wire bonding as shown in Fig. 2.
- The bonded ball contact area, an item that could be extracted from the predicted FAB shape, is very important to establish excellent electrical connection.

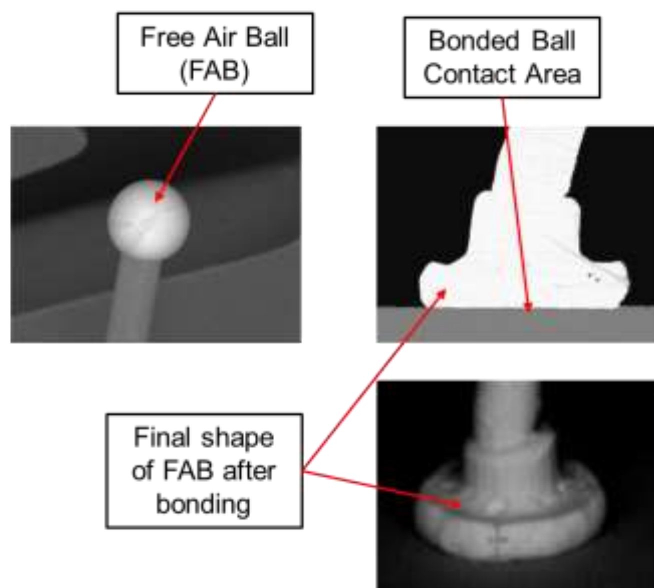

Fig. 2. Actual wire binding free air ball (FAB) before bonding and after bonding to die bond pad.

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III. Finite Element Modeling

- Finite element modeling was used to predict the final shape of the free air ball (FAB) after wire bonding.
- The FAB material was modeled with bilinear kinematic (elastic-plastic) properties in ANSYS LSDyna software.
- Fig. 3 shows the finite element model used for FAB shape prediction.
- All the details of the capillary, bond wire diameter, FAB size and capillary distance from bond pad were included in the model.

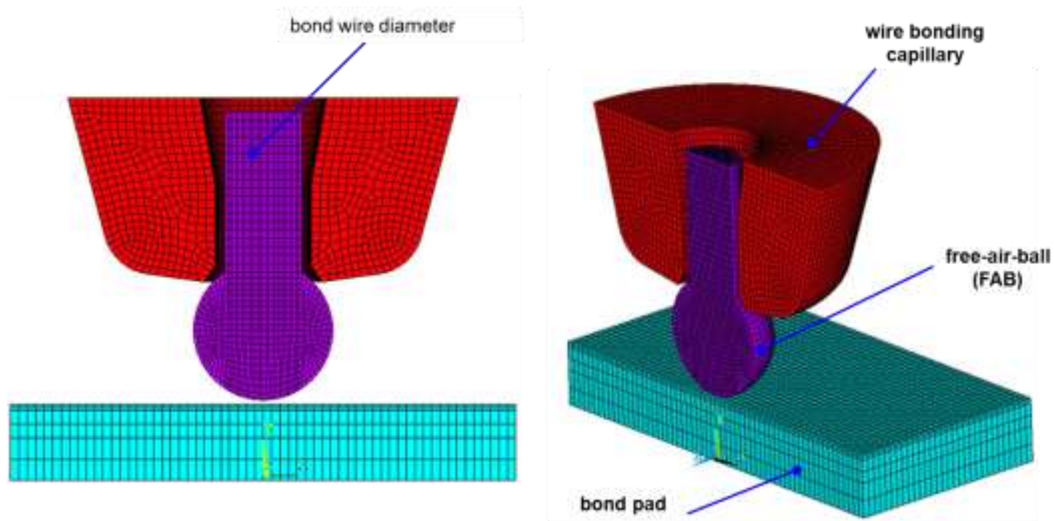


Fig. 3. Finite element model used in FAB shape prediction.

IV. Modeling Results and Prediction

- As shown Fig. 4, the final FAB shape after wire bonding closely matches with actual FAB shape.
- Dimensional details were also extracted and a relationship between the FAB size and bonded ball contact area was established as indicated in Fig. 5.
- Based on the results, finite element modeling has been proven to be a useful technique for FAB size prediction in semiconductor package wire bonding interconnection.

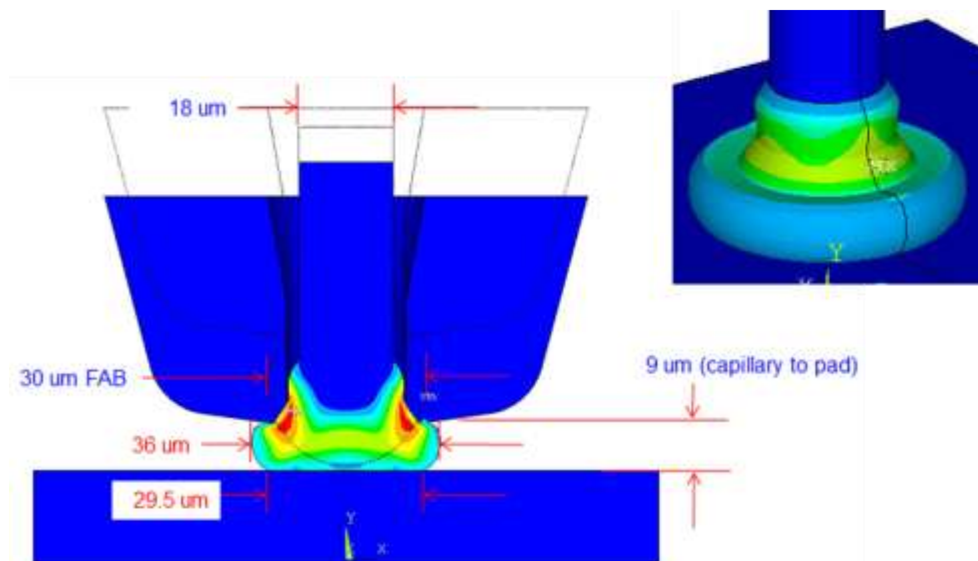
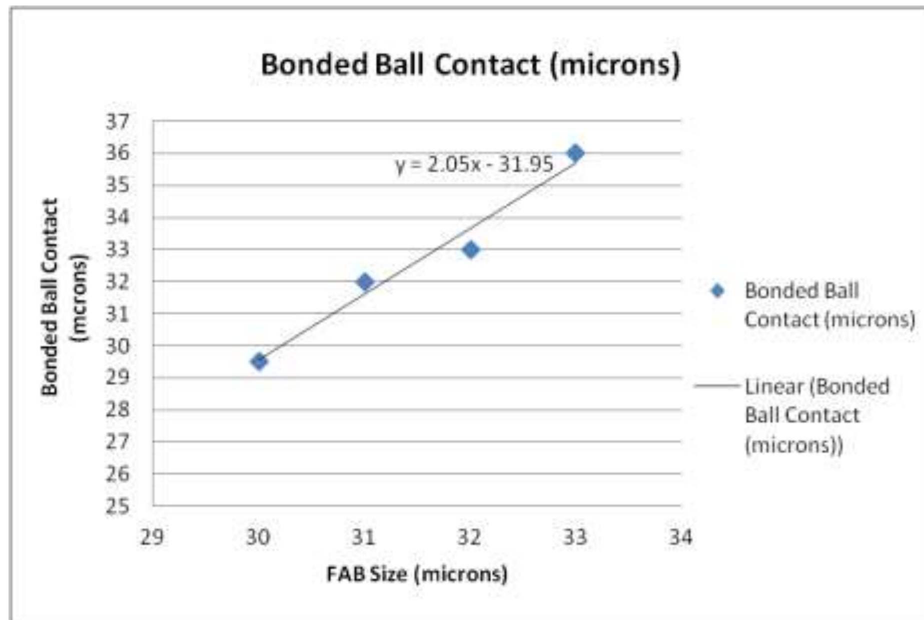


Fig. 4. Modeling result showing the final FAB shape for the 30 µm FAB diameter .



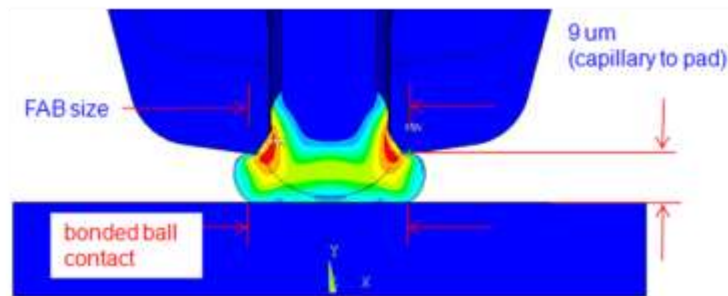


Fig. 5. Relationship between FAB size and bond ball contact.