ADVANCED IC PACKAGING TECHNOLOGIES, MATERIALS, AND MARKETS

2017 EDITION

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Chapter 1
Introduction

1.1 Objectives of the Report

This 2017 edition of *Advanced IC Packaging Technologies, Materials, and Markets* provides a detailed analysis and forecasts for a particularly important segment of the global integrated circuits (ICs) packaging industry. Much of the data underlying this report is taken from New Venture Research's *Worldwide IC Packaging Markets, 2016 Edition*. However, where that report provides a broad overview of the entire IC packaging market, this report focuses, instead, on the most advanced types of IC packages being developed and shipped today, as well as on new techniques and materials used in manufacturing advanced IC packaging solutions.

This report provides information critical for companies involved in semiconductor manufacturing and IC assembly and test, and is designed to aid executives and management within sales, business development, and marketing organizations in making important strategic and product development decisions. Toward that aim, it provides both qualitative analysis of the covered market segments, and current statistical data and forecasts that will enable companies and individuals to better understand the status of—and to anticipate market and technology trends in—the rapidly evolving advanced IC packaging and materials market.

1.2 Scope of the Report

The manufacturing of semiconductors is an extremely complex and capital-intensive process. In its most simplified form, the manufacturing process requires five major steps: circuit design, wafer fabrication, wafer test, assembly and packaging (the words are sometimes used synonymously), and final test. The first three steps are collectively known as the "front end" and involve the design and production of the semiconductor devices; the fourth and fifth steps are the "back end" and are often referred to as simply "assembly and test."

This report focuses on the assembly or IC packaging step of the process, and the companies that provide IC packaging products and solutions. Further, the subjects of this report are the most advanced forms of IC packaging solutions being delivered today. Specifically, the products and technologies covered in this report include:

- Fan-out wafer-level packages (FOWLPs)—this recent advancement provides a reliable means of expanding the number of leads or connections beyond the range of standard wafer-level packages and is one of the hottest markets in the semiconductor industry today.
- Multi-row quad flat pack no lead packages (MRQFNs)—this new packaging technique has given new life to the mature QFN market segment by enabling manufacturers to greatly expand the number of contacts beyond what traditional single-row QFNs are capable of supporting.
- Stacked IC packages—these packages combine multiple ICs of a given type in vertical stacks that are then packaged as a single chip. Specific market segments that are analyzed include thin small outline packages (TSOPs), fine-pitch ball grid arrays (FBGAs), quad flat pack no lead packages (QFNs), and wafer-level packages (WLPs).
- System-in-package solutions—these packages combine not just stacks of one type of device, but a variety of active memory, logic, or analog devices, as well as passive components. Examples of these advanced packages are package-in-packages (PiPs), package-on-packages (PoPs), and multichip modules (MCMs).
- Advanced interconnection technologies, specifically flip chip and through-silicon vias (TSVs). An examination of current trends in traditional wire bonding techniques is included in this analysis of interconnection techniques.
- Substrate materials and technologies that augment the advances achieved with multichip packages.

Each market segment covered in this report includes an overview of the technology and general market trends, plus quantitative analyses with forecasts of unit shipments, revenues, pricing, etc. Data in tables covers the historical years 2015 and 2016, with forecasts provided through 2021.

In addition, we provide individual profiles of selected competitors in the advanced IC packaging marketplace. The field of manufacturers that provide IC packaging solutions is quite large and varied. The largest and (mostly) oldest semiconductor companies—IBM, Intel, Fujitsu, Mitsubishi, NEC, NXP (formerly a division of Philips), and Samsung, to name a few—have the internal resources to carry out both front- and back-end processes in the semiconductor manufacturing process. These have come to be known as integrated device manufacturers (IDMs). However, changing priorities and market pressures have given rise to numerous wafer

foundries that specialize only in the front-end manufacture of semiconductors and to other companies that specialize solely in the back-end processes. These latter are collectively known as outsourced semiconductor assembly and test companies (OSATs). The twenty-one profiles in this report include those of competitors from across the spectrum of semiconductor companies, but focus primarily on OSATs that have developed advanced IC packaging product lines.

1.3 Report Organization

1.3.1 Chapter Outline

This report is organized into six chapters, plus a Glossary:

- Chapter 1 Introduction—Outlines the scope and organization of the report.
- Chapter 2 Executive Summary—Provides an overview of the market and highlights of the top-level market segments.
- Chapter 3 Overview of Worldwide IC Packaging Markets—Provides a brief review of the global IC packaging marketplace more fully detailed in the companion report, *The Worldwide IC Packaging Market, 2016 Edition*. This chapter also analyzes the application trends for IC packaging markets, as well as more general industry trends driving the entire semiconductor sector. Market data and forecasts are provided for each market segment.
- Chapter 4 Advanced Packaging Markets—Describes the market and technology trends both advanced IC packaging products, as follows:
    - Fan-out wafer-level packaging (FOWLPs)
    - Multi-row QFNs (MRQFNs)
    - Stacked packages, specifically stacked TSOPs, stacked FBGAs, stacked QFNs, and stacked WLPs
    - System-in-packages (SiPs), specifically package-on-packages (PoPs), package-in-packages (PiPs), multichip modules (MCMs), and stacked WLPs used within SiPs

  Also discusses advances in substrate material technology as used with SiPs. Market data and forecasts of unit shipments and revenues of each market segment are provided, with additional market segmentation as befits the product.

- Chapter 5 Interconnection Technologies and Solutions—Briefly describes the market and technology trends of wire bonding, the dominant type of interconnection for all packaging technologies, and the metals used with wire bonding. The major part of the chapter provides technology and market trends for flip chip interconnection, with the market segmented by packaging types and IC devices used with flip chip. The final section of the chapter discusses through-silicon vias (TSVs). Market data and forecasts of unit shipments and revenues are provided for each market segment.
- Chapter 6 Advanced IC Packaging Company Profiles—In-depth profiles of industry participants.
- Glossary of packaging and semiconductor terms.

1.3.2 Methodology

The information presented in this report was gathered from a variety of primary and secondary sources. Both qualitative and quantitative data were provided by marketing and business development managers at IC packaging manufacturers and other semiconductor-related companies through responses to detailed surveys. In addition, extensive use was made of publicly available materials, including company Web sites and literature such as press releases and investment reports, as well as articles and white papers obtained through the Internet, online databases, and trade publications. We have utilized these varied resources to ascertain market trends and in preparing the tables and figures appearing throughout this report. However, the author and New Venture Research are the sole and exclusive originators of the specific historical and forecast data presented in this report, and are responsible for its content.

1.3.3 Grammatical Conventions

Perhaps more than most, the electronics sector tends to use terminology in a unique and sometimes confusing way. Abbreviations or acronyms for both technical and nontechnical terms are very common—but not very consistent. For example, the standard dictionary method of abbreviating the term *three-dimensional* is "3-D." However, in trade press articles and on the Internet and even in scientific papers, we see the abbreviation variously as *3-D, 3D,* or *3 D*. Similar variations are true for many common semiconductor and packaging terms.

For purposes of this report, we use the following conventions for spelling of common technical and not-so-technical terms:

- 2D, 2.5D, and 3D to abbreviate the types of packaging discussed throughout the discussion of multichip packaging
- Flip chip (no hyphen, two words)
- Multichip packaging, multichip modules, multicomponent ICs, etc. (no hyphen, one word), but single-chip packaging and multi-row QFN.
- Packaging types such as FBGA and WLP are all caps as acronyms, but when spelled out, no capitalization is used; thus, fine-pitch ball grid array and wafer-level package.
- Other acronyms may vary as to capitalization. In particular, terms that include prepositions, such as system-in-package (with hyphens), package-in-package, and package-on-package are rendered as SiP, PiP, and PoP, respectively. The Internet of Things (note the caps) is abbreviated as IoT. Similarly, the term "year-over-year," which appears in tables throughout the report, is abbreviated "YoY."

Where a specific product or brand names differ from our conventions, especially in the case of trademarked and registered names, the formal name takes precedence—for example, Siliconware's "Multi-Package BGA" or the company "FlipChip International." The Glossary provides the spelling of words and phrases that appear throughout this report.

Finally, we should point out that there are few direct quotes to be found in this report, although we have consulted many sources, including traditional publications and Internet-only sources (blogs, e-zines, etc.), as well as direct contacts with industry participants. Care has been taken that the text used throughout this report is our own. However, where the resource is in the public domain—such as Web-based marketing material or text and images placed on the Internet and intended for public consumption—a limited amount of verbatim text may be used. To be specific, managers may recognize in their company profiles some descriptive materials as it pertains to their own company and products. In no way, however, do we intentionally plagiarize or make public proprietary information that has been provided in confidence to NVR or the author of this report.