Technologies Supporting Compactness and Slimness

OZAKI Kazuya, KONDOU Hiroaki, NAKAO Junichi, YAMAMOTO Hikaru

Abstract

Recently, mobile terminals have been subjected to strong pressures calling for size/thickness reductions as well as for enhancements and multiplication of functions. NEC is promoting the size/thickness reduction of its developed models by deploying size/thickness reduction technologies to all new products by releasing optimally sized early prototypes. We are tackling the development of various component technologies aimed at size/thickness reductions for use in pre-prototypes and have recently developed the world's slimmest 3G flip-phone terminal of slightly more than 9mm thickness.

This advance was achieved by deploying our technical assets to further enhance our products; NEC is promoting additional value to its entire mobile phone lineup by applying the benefits of size/thickness reduction.

Keywords

cellular phone, size/thickness reduction, packaging method, cabinet construction key structure, speaker, FPC connection

1. Introduction

Recently, the diversification of user needs in the mobile phone market is increasing the tendency to emphasize size and design as well as calling for further enhancements and multiplication of functions. In particular, the preference for slimmer models has been increasing year on year, making the slimness of equipment a key factor in user preference in mobile terminals choice.

NEC is currently leading the trend toward size/thickness reduction in the mobile phone market by developing and shipping ultra slim terminals. This paper introduces the efforts that have been made so far toward reducing the size/thickness of mobile terminals and discuss the technologies that have been employed.

2. Efforts Aimed at Reducing Size/Thickness

At NEC, in addition to the promotion of size/thickness reduction of all of the products that we develop, we are deploying size/thickness reduction technologies to our products by developing minimal sized early prototypes in an effort to foster relevant technologies as competence of our expertise. This strategy consists of the development of minimally sized pre-prototypes that incorporate size/thickness reduction elements, and product development aids such as stacking the additional

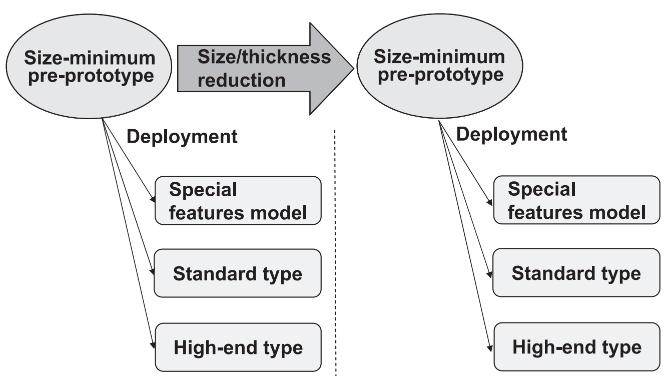

Fig. 1 Deployment of size and thickness reduction to devices via early prototype development.

functions based on the basic configuration of the prototype (**Fig. 1**). This strategy has enabled us to optimize the compact/slim designs according to various kinds of products, including high-end terminals that require a high component packaging volume and terminals with special features that require decorative parts for their special designs.

In the development of the equipment for minimal size dearly prototype, we are developing appropriate element technologies for size/thickness reduction jointly with System Jisso Research Laboratories. The results of the incorporation of our achievements as described above, the accurate identification of issues and the correct solutions to them have allowed us to develop a pre-prototype for the 3G flip phone terminal with

Photo Early prototype of the world-slimmest 3G flip-phone with a thickness of 9mm.

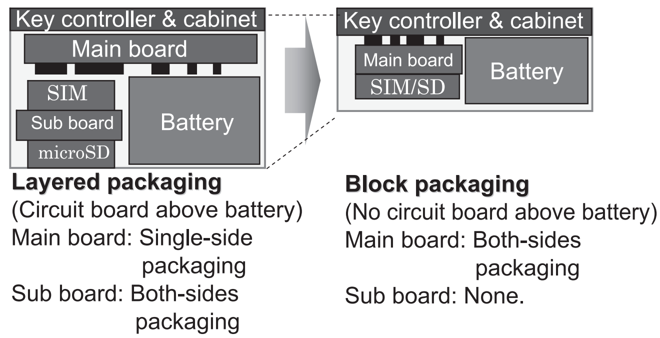

Fig. 2 Differences between layered packaging and block packaging.

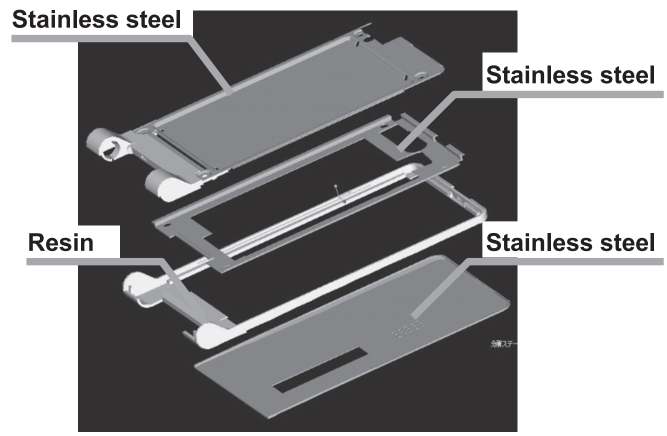

Fig. 3 Hybrid cabinet of early prototype.

the world's smallest thickness of slightly more than 9mm (**Photo**). The following section describes the main size/thickness reduction technologies that were implemented in the development of this prototype.

3. Development of Size/Thickness Reduction Elements

3.1 Block Packaging

The thickness reduction of mobile terminals requires high efficiency in component packaging and PCB design. In particular, the battery and the adjacent components are the bulkiest parts in the mobile terminal and must be packaged by eliminating their effects on equipment thickness as much as possible. **Fig. 2** shows the difference between the layered packaging method used in the traditional packaging of mobile terminals and block packaging. Layered packaging superimposes the PC board, electrical components and battery in layers but block packaging places them in adjacent blocks, thus making it possible to reduce the overall equipment thickness. However, block packaging is not possible unless the PCB area is reduced. The pre-prototype has made block packaging possible by developing a new 3G mobile phone platform that occupies about a half of the packaging volume of the terminals that were commercialized two years ago.

3.2 Hybrid Cabinet

The need for thickness reduction of mobile terminals has necessitated a reduction both in the cabinet thickness and for the retention of cabinet strength and rigidity. If the strength and rigidity of the casing are low, it may easily become twisted or distorted by any impact incurred if it is dropped. Dropping may also cause a failure such as cracking of the LCD glass or separation of the solder of the electrical components.

To deal with this issue by increasing the strength of the casing and securing its rigidity, we have adopted a hybrid cabinet for the early prototype that integrates resin and metal. With the hybrid cabinet (**Fig. 3**) of the early prototype, the internal frame uses a stainless-steel sheet formed into a bathtub shape by a drawing process and the LCD panel is dropped into the frame. The cabinet rigidity is increased by integration of the resin forming process for the cabinet hinge with the above-described stainless-steel plate. In addition, the material of the outer side of the rear cabinet is changed from the previous resin to a stainless-steel plate and another stainless-steel plate is

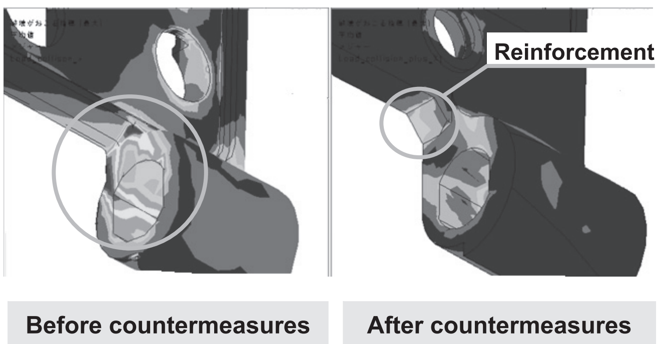

Fig. 4 Stress simulation results.

added to the area that is not superimposed in layers with electrical components such as the speaker to act as an internal reinforcement frame. The resin parts that come on the outermost surface of the side panels are inserted and attached by thermal adhesion and the screw bosses are welded onto the internal reinforcement frame and are attached to the LCD-side cabinet with screws. As a result a total of three stainless-steel plates are combined strongly in order to provide both reduced thickness and increased rigidity.

To study the measures for increasing the strength and rigidity of the cabinet, we performed the cabinet construction design by applying stress simulations. We also adjusted the cabinet shape of the early prototype so that stress would not be concentrated at the hinge seating.

Fig. 4 shows the results of a stress simulation near to the hinge seating. As some stress concentrations were observed initially, we applied countermeasures for optimizing the stress by increasing the thickness at the stress concentration positions.

3.3 Bathtub Key/Cabinet Integrated Construction

When the block packaging as described above is used, it becomes necessary to prepare a separate mechanism for supporting the keys. Since most important concern of the operability of mobile phone keys is not to adversely affect the feeling of the clicks, the issue is to ensure compatibility between the thin key structure and a tactile click feeling.

We adopted a bathtub structure as the means for solving the above issue with the early prototype (**Fig. 5**). With this structure, the integrated casting of a drawing processed stainless-steel plate and the resin part has made it possible to implement the fixed structure around the keys on a film, which has

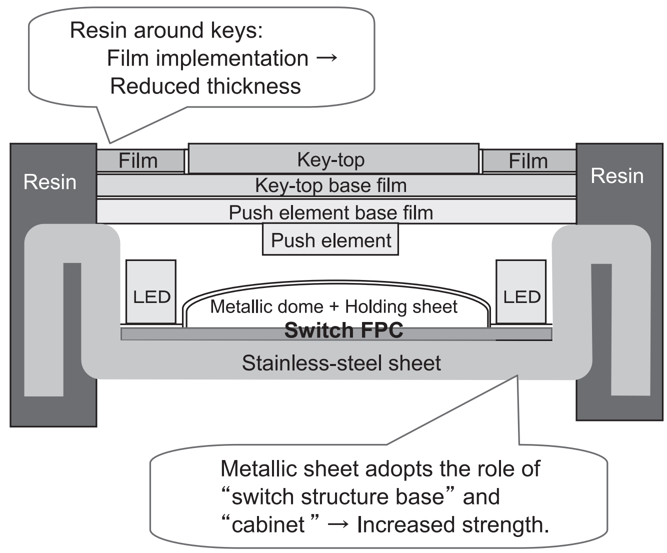

Fig. 5 Bathtub structure.

previously been formed using resin. This has enabled thickness reduction of the key cabinet as well as provision of sufficient click feeling, thanks to the use of the highly rigid, warp resistant stainless-steel plate in the part that supports the keys.

3.4 Thin–Film Piezoelectric Speaker

Slim packaging of acoustic components such as the speaker and microphone is another issue in the reduction of the equipment thickness. In particular, the dynamic speakers used in previous models needed a thickness of about 3mm for the speaker unit alone and the thickness of the rear air chamber that increases the acoustic pressure is additionally required. We solved this issue by developing an ultra-slim piezoelectric ceramic speaker with a thickness of 0.89mm for the early prototype. For the speaker packaging method, we reserved maximum thickness for the rear air chamber by adopting the method of attaching the speaker to the rear cabinet using double-side adhesive tape. In order to reduce unnecessary oscillations that might occur due to the modification of the rear cabinet material from resin to stainless-steel plate we placed cushioning material near the speaker components and inserted it between the highly rigid front hybrid cabinet and the rear cabinet that supports the speaker. This measure has improved the acoustic pressure characteristic by 6 to 10dB even in the low-frequency range, which has made it possible to provide an

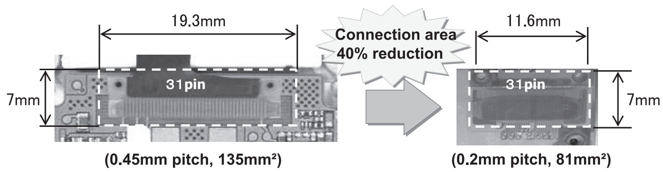

Fig. 6 Area reduction effect of narrow-pitch connection (Applied to 2 points on the unit).

equivalent acoustic pressure to that of traditional dynamic speakers.

3.5 Narrow-Pitch FPC Connection Technology

The terminals previously adopted an ACF connection with a 0.45mm pitch for the connection between the main and R boards, but the early prototype uses a smaller packaging area that necessitates a connection with a 0.2mm pitch. However, a clamping connection with a narrow-pitch is accompanied with the risk of a drop in the connection strength due to the reduced connection area and a drop in the insulation value due to the reduced clearance between chip lands. In addition, the traditional ACF using conducting particles poses a special problem in maintaining insulation reliability because conducting particles tend to get between the terminals.

We dealt with this problem and secured insulation by developing a connection material without conducting particles. In the new connection method, the chip lands on a circuit board are contacted directly without using conducting particles, so extremely high insulation reliability may thus be achieved. The connection uses a thermoplastic resin material in order to significantly improve the reparability at the same time as securing connection reliability. By adopting this connection technology, we have succeeded in reducing the connection area by 40% (**Fig. 6**).

4. Conclusion

As described in the above, we have developed practical components in support of size/thickness reductions and have applied them to an early prototype of the world's slimmest 3G mobile phone. We are also promoting the addition of innovative values to our entire mobile phone lineup that offer the added benefits of size/thickness reductions.

It is expected that mobile terminals in the market will advance and diversify their shapes and designs. In the future, too, we will continue our best efforts toward further size/thickness reductions for the packaging. We consider that this strategy is fundamental for the implementation of the advanced and diversified designs that are capable of achieving optimally sized devices.

Authors' Profiles

OZAKI Kazuya
Senior Manager,
Mobile Terminals Technologies Division,
Mobile Terminals Products Development Operations Unit,
NEC Corporation

KONDOU Hiroaki
Expert,
Mobile Terminals Technologies Division,
Mobile Terminals Products Development Operations Unit,
NEC Corporation

NAKAO Junichi
Assistant Manager,
Mobile Terminals Technologies Division,
Mobile Terminals Products Development Operations Unit,
NEC Corporation

YAMAMOTO Hikaru
Staff,
Mobile Terminals Technologies Division,
Mobile Terminals Products Development Operations Unit,
NEC Corporation