UNIVERSITAS KRISTEN PETRA

Juliana Anggono <julianaa@petra.ac.id>

Paper Gan Shusan

Fandi D. Suprianto <fandi@petra.ac.id> Mon, Apr 8, 2019 at 5:31 PM
To: Shusan Gan <gshusan@petra.ac.id>
Cc: Juliana Anggono <julianaa@petra.ac.id>

Dear Bu Shusan,

Berikut ini kami sampaikan hasil review dari reviewer. Mohon direvisi sesuai dengan masukan dari reviewer, kemudian dikirimkan kembali ke saya sebelum 16 April. terimakasih.

Salam,
Fandi.

On Sun, Feb 24, 2019 at 1:11 AM Juliana Anggono <julianaa@petra.ac.id> wrote:
[Quoted text hidden]

Review Paper GSS.docx
13K

Relevance (*). The relevance of the topic for Automotive or Manufacturing or Mechanical Engineering researches
5: excellent
4: good
3: fair (V)
2: poor
1: very poor

Contribution to academic debate (*). Contribution to academic debate, including intellectual significance, novelty of the finding, and insight contained
5: excellent
4: good (V)
3: fair
2: poor
1: very poor

Structure of the paper (*). The paper is clearly and sensibly arranged
5: excellent
4: good (V)
3: fair
2: poor
1: very poor

Standard of English (*). Quality and clarity of the writing
5: excellent
4: good (V)
3: fair
2: poor
1: very poor

Title, abstract, and keywords (*). Appropriateness of title, abstract, and keywords/key phrases as a description of the paper
5: excellent
4: good (V)
3: fair
2: poor
1: very poor

Research/study method (*). Appropriateness of the research/study method, including the adequacy of technical/analytical method, data, calculation & analysis (when applicable)
5: excellent
4: good
3: fair (V)

2: poor
1: very poor

Clarity (*). Relevance and clarity of drawings, graphs, tables and abbreviations and formulas
5: excellent
4: good (V)
3: fair
2: poor
1: very poor

Discussion and conclusions (*). Relevance and the depth in interpreting and evaluating the findings; Main conclusions are clearly stated.
5: excellent
4: good
3: fair (V)
2: poor
1: very poor

References (*). References are adequate and properly cited
5: excellent
4: good (V)
3: fair
2: poor
1: very poor

Overall evaluation (*). Please provide a detailed review, including a constructive feedback for the author(s). Both the score and the review text/comments are required.
3: strong accept
2: accept (V)
1: weak accept
0: borderline paper
-1: weak reject
-2: reject
-3: strong reject

Comments:
(1) For Indonesian people who tend and prefer to by new product, the possibility to remanufacture these kind of products are still questionable.
(2) Is there any market for these products (especialy in Indoesia) if the price of the new mobile phones still affordable?

UNIVERSITAS KRISTEN PETRA

Juliana Anggono <julianaa@petra.ac.id>

Jurnal ICAMME paper 66 Revisi

Juliana Anggono <julianaa@petra.ac.id> Thu, Jul 18, 2019 at 6:57 AM
To: ma'ruf Nurwantara <makrufpambudinurwantara@gmail.com>
Cc: Shusan Gan <gshusan@petra.ac.id>, Novana Hutasoit <nhutasoit@swin.edu.au>

Dear Pak Ma'ruf,

Terlampir kami kirimkan paper 66 yang sudah direvisi dan sudah kami tambahkan juga author dari manca negara. Mohon dicek dan bisa diterima. Terimakasih.

regards,
Dr. Juliana Anggono
Associate Professor
Mechanical Engineering Department
Petra Christian University
Surabaya 60236 Indonesia

IC-AMME_2018_paper_66 (revisi JA)-1-NHU-GSS.doc
1933K

A Feasibility Study of Mobile Phone Casings Remanufacturing ~~Characterization of Mobile Phone Casings for Remanufacturing Purpose~~

Shu-San Gan[1], *Juliana* Anggono[1*], *Didik* Wahjudi[1], *Yopi* Tanoto[1], ~~and~~ *Randy*[1] and Novana Hutasoit[2]

[1]Mechanical Engineering Department, Petra Christian University, Surabaya, Indonesia

[2]Mechanical and Product Design Engineering Department, Swinburne University of Technology, Hawthorn, Australia

Abstract. Remanufacturing is a process when used product or core is brought to 'like-new' condition, might be with an upgrade in performance. This process complies with technical specifications, including engineering, quality and testing standards. It yields a fully warranted product. The purpose of this study was to conduct an initial study on the feasibility of remanufacturing ~~specifically~~ primarily on the mobile phone casings to provide information and consideration for a firm that would conduct remanufacturing of mobile phones. A series of material characterization on several mobile phone casings manufactured by major international brands revealed that remanufacturing is not a viable route to attempt. The evaluation shows that remanufacturing used casing mobile phone require ~~A material characterization on the mobile phone casings was performed to evaluate the material structure for remanufacturing consideration. The results show that mobile phone casings are not suitable for remanufacturing, based on the material analysis~~several stages of repair which cause the **increase** in the **cost** that can in turn affect the prices.

~~process difficulty, as well as cost projection. Several stages of repair during remanufacturing work will be required and the cost~~

Keywords: Material characterization, electronic goods, recovery process, casing material.

1 Introduction

Rapid development in mobile phone technology during the last decade has resulted in the availability of various brands and specifications of mobile phones in the market. The growing dependence on smartphones as well as availability of brands offering higher specification devices at affordable price have triggered a faster upgrade cycle or in other words reduced the smartphone replacement cycle. Furthermore, the number of discarded mobile phones increases significantly, either from damaged mobile phones or merely outdated models, which will become electronic wastes or e-waste. According to Baldé et

* Corresponding author : julianaa@petra.ac.id

Formatted: Font: (Default) Arial, 16 pt, Bold
Formatted: Font: (Default) Arial, 16 pt, Bold
Formatted: Font: (Default) Arial, 16 pt, Bold
Formatted: Font: (Default) Arial, 16 pt, Bold
Formatted: Font: (Default) Arial, 16 pt, Bold
Formatted: Font: (Default) Arial, 16 pt, Bold
Formatted: Font: (Default) Arial, 16 pt, Bold
Commented [A1]: Tolong balon komentar jangan dihapus
Commented [KH2]: Usulan judul 'A feasibility study of mobile phone casings remanufacturing '
Commented [SSG3R2]: setuju
Formatted: Superscript
Formatted: Superscript
Formatted: Superscript
Formatted: Superscript
Formatted: Font: Not Italic, Superscript
Formatted: Font: (Default) Times New Roman, 10 pt
Formatted: Superscript
Formatted: Superscript
Formatted: Space Before: 0 pt
Formatted: Superscript
Formatted: Font: (Default) Times New Roman, 9 pt
Formatted: Font: 9 pt
Formatted: Font: (Default) Times New Roman, 9 pt
Formatted: Font: (Default) Times New Roman, 9 pt
Commented [KH4]: primarily
Commented [SSG5R4]: done
Formatted: Font: (Default) Times, 9 pt
Commented [KH6]: A series of material characterization on several mobile phone casings manufactured by major international brands revealed that remanufacturing is not a viable route to attempt.
Commented [KH7]: Komposisi kimia ?
Formatted: Font: (Default) Times
Formatted: Font: Not Bold
Commented [KH8]: complexity. Kesulitan apa yang di temukan ?
Formatted: Font: (Default) Times
Commented [N9]: Tolong diganti dengan kata yang mencerminkan judul. Keywords berbeda dengan judul
Commented [SSG10R9]: Sudah diganti, namun sebenarnya « remanufacturing » harus ada di keyword karena kalau diganti ...

al. [1], e-waste reaches 41.8 × 10^9 kg in the world consisting of 1 × 10^9 kg of waste lamps, 3 × 10^9 kg of small electronic goods waste, 6.3 × 10^9 kg of electronic display, 7 × 10^9 kg of temperature control waste, 11.8 × 10^9 kg of large electronic equipment waste and 12.8 × 10^9 kg of small electronic equipment. Mobile phone is categorized as small electronic goods. Therefore, one way to overcome that waste problem is by performing remanufacturing.

~~According to Franke et al. [2], Tong [3], and Rathore et al. [4], remanufacturing is a promising recovery process for electronic products and mobile phones. Other studies by Quariguasi-Frota-Neto and Bloemhof [5], Xing et al. [6], and Kwak and Kim [7] showed that it was profitable.~~

Commented [KH11]: Bagian ini kelihatannya menerangkan keuntungan dari remanufacturing sehingga lebih cocok ditempatkan sesudah kalimat 'Recently, remanufacturing activities are intended for products that have a very expensive price and have a reasonable component size to be remanufactured [10].' Apakah perbedaaan antara recovery dan remanufacturing? Tambahan kalimat yang menerangkan perbedaaan ini membantu pembaca untuk mengerti terminology teknis yang digunakan di paper ini.

2 Methodology

There are three types of materials that are commonly used for mobile phone casings in Indonesia, which are aluminum alloy, plastic, and glass. The study was conducted in two phases: (i) an interview process with a mobile phone manufacturer and several mobile phone users to understand their view on the possibility of doing mobile phone remanufacturing, (ii) material characterization using Scanning Electron Microscopy (SEM) and Energy Dispersive X-Ray Analysis (EDAX) to analyze the structure of casing materials casings including their manufacturing process. The results show that mobile phone are not suitable for remanufacturing, based on the material analysis, process difficulty, as well as cost projection.

The mobile phones which were used for materials characterization were selected from three different brands representing brands from Unites States (Apple), South Korea (Samsung), and China (Redmi). Those three brands had their casings made from aluminum alloy, plastics, and glass (Table 1).

Table 1. Mobile phone selection for material characterization.

Brand	Model	Casing material
Apple	iPhone 5	Aluminum
Xiaomi	Redmi 3	Aluminum
Samsung	Galaxy S5	Plastic
Samsung	Galaxy S6	Glass

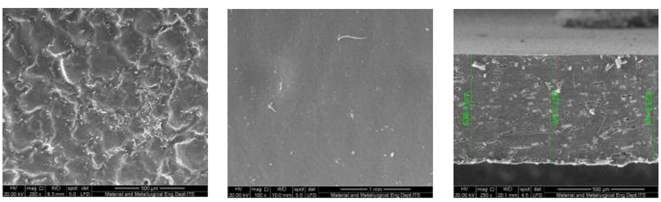
Study of the material structure and composition of the phone casings was conducted using SEM and EDAX analysis for iPhone, Redmi, and Samsung S5. Meanwhile for phone casings made from glass (Galaxy S6), a literature study from Corning's gorilla glass was used as a reference. Upon completing the characterization and obtaining information from interviews with national smartphone manufacturer and users, those results were analyzed to provide some recommendations for remanufacturing.

3 Results and discussion

Evaluation with SEM and EDAX was performed on the back cover section at three different locations, i.e. at the top surface, cross sectional area, and at the bottom surface of each evaluated casing piece. The materials evaluated were aluminum alloy (iPhone 5 and Xiaomi Redmi 3) and plastic (Samsung Galaxy S5).

3.1 Plastic: Samsung Galaxy S5

Figure 1 shows SEM images ~~from~~ at three different regions~~areas~~ ~~of~~ in ~~cut~~ observed sample of Samsung Galaxy S5 casing. The areas studied were top surface, bottom surface, and cross sectional area. It can be seen from Figure 1(c) that this casing is made from plastic material with a minimum thickness of 623.6×10^{-6} m and maximum ~~of~~ to 636.4×10^{-6} m. There was no coating applied on this plastic casing. Chemical composition tests with EDAX confirmed this plastic material in which their major constituent elements are mainly carbon and oxygen as shown in Table 2. The type of plastic ~~made for the casing~~ is polycarbonate which manifests high [illegible] also lighter, compared to metal casing and does not conduct heat well therefore there is no cold feeling when holding it. Polycarbonates are much cheaper to form and mold than metal or glass.



(a) (b) (c)

Fig. 1. SEM micrographs of material casing of Samsung Galaxy S5 (a) top surface, (b) bottom surface and (c) cross sectional area.

Table 2. Chemical composition of plastic material in Samsung Galaxy S6.

Casing section	% Weight		
	Carbon	**Oxygen**	**Magnesium**
Top	58.02	29.67	-
Bottom	63.96	28.84	-
Cross section	55.55	34.65	-

3.2 Aluminum: Apple iPhone 5 and Xiaomi Redmi 3

SEM studies observed that this Xiaomi Redmi 3 consisted of aluminium alloy casing with a coating layer adhered to it with a minimum thickness of 8.218×10^{-6} m to a maximum of 8.975×10^{-6} m (Fig. 2b) or nearly twice the coating layer thickness identified on iPhone 5 (Fig. 2a).

~~Similar SEM and EDAX studies were performed on casing materials from Apple iPhone 5 and Xiaomi Redmi 3. Figure 2 shows the SEM images from the cross sections of the iPhone 5 and Redmi 3.~~

Formatted: Font: (Default) Times, 10 pt

Commented [U17]: Mohon ditambahkan beberapa kalimat sebagai pengantar literasi

Commented [WU18R17]: Sudah direvisi

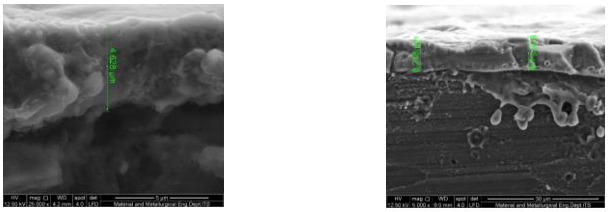
Commented [KH19]: Manifests high strength and toughness, therefore, do not deform easily compared to metal phone casing

Commented [WU20R19]: done

Formatted: Font: (Default) Times, 10 pt

Formatted: Font: (Default) Times, 10 pt

Commented [KH21]: Consider to remove these sentences.



(a) iPhone 5 (b) Xiaomi Redmi 3

Fig. 2. SEM micrographs of cross-sectional of aluminum casings.

~~SEM studies observed that this Xiaomi Redmi 3 consisted of aluminium alloy casing with a coating layer adhered to it with a minimum thickness size of 8.218 × 10⁻⁶ m to a maximum of 8.975 × 10⁻⁶ m (Fig. 2b) or nearly twice the coating layer thickness identified on iPhone 5 (Fig. 2a).~~ The Apple phone used aluminium alloy 7000 series that was stated as its Apple's Patent Pending. This type of alloys has high yield strength such that the alloys do not dent easily [12]. Table 3 explains that the amount of oxygen in iPhone 5 is significantly high due to the anodizing process for its coating, while in Redmi 3, it uses spraying for coloring.

Table 3. Chemical composition of aluminium alloy in iPhone 5 and Redmi 3.

Casing Horizontal	% Weight							
	C	**O**	**Mg**	**Al**	**Si**	**S**	**K**	**Ca**
iPhone 5	31.66	1.07	1.37	35.02	24.76	1.46	1.78	2.87
Redmi 3	8.55	--	2.35	68.73	1.22	1.51	--	--

3.3 Glass: Samsung Galaxy S6

Samsung Galaxy S6 used Gorilla glass 4 which was introduced in November 2014. Until ~~now~~ present time, Corning has marketed Gorilla glass 6 (has a ~~higher level of compression~~compresive strength due to chemically strengthened surface produced through new glass composition compared with Gorilla Glass 5) which was introduced in 18 July 2018 and twice better than Gorilla glass 5 [13, 14]. Most ~~of the~~ mobile phone companies that use glass material for the casing, ~~they~~ use Corning gorilla glass. In this research, the studied mobile phones were within the age of two to five years, therefore the gorilla glasses that were discussed in this section were of series 4 and 5.

From the reference provided by Corning Inc [13, 14], it appears that Gorilla Glass 6 has the highest durable level compared to the previous series as described in Figure 3.

In a drop test (Figure 3a), a pendulum and an emery paper of 180 were used. The glass attached to the pendulum will be dropped from a certain distance and hit the emery paper of 180. The damage resistance of Gorilla Glass 5 increases by 1.5 up to 1.8 times compared to glass 4. The glass thickness parameter is set from 0.4 to 0.8 because there are differences in thickness produced by Corning for Gorilla Glass 4 and Gorilla Glass 5. As in Figure 3(b) it can be seen that Gorilla Glass 5 is able to withstand 10 % more scratches in pressure of 3 462.122 407 5 Pa and 65 % more in 6 231.820 333 5 Pa pressure compared to Gorilla Glass 4.

Formatted: Justified

Commented [KH22]: di hapus

Commented [SSG23R22]: sudah dihapus

Commented [KH24]: a maximum of

Commented [SSG25R24]: sudah direvisi

Commented [KH26]: Kelihatannya bagian ini bisa jadi paragraph pertama di bagian '**3.2 Aluminum: Apple iPhone 5 and Xiaomi Redmi 3 '.**

Commented [U27]: Mohon diperjelas dalam penulisan sitasi dan penggunaan kalimatnya

Commented [WU28R27]: Sudah diperbaiki

Commented [KH29]: Present time,

Commented [SSG30R29]: sudah direvisi

Commented [KH31]: Compressive strength

Commented [SSG32R31]: sudah direvisi

Commented [KH33]: Consider to remove these words

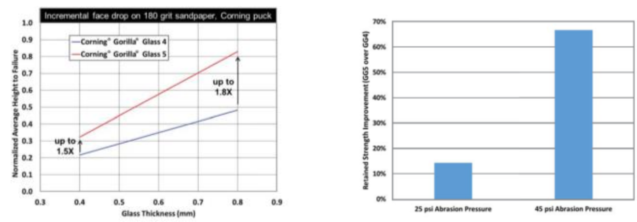
Commented [SSG34R33]: sudah dihapus

Commented [KH35]: Consider removing this word

Commented [SSG36R35]: sudah dihapus

Commented [U37]: Mohon diganti dengan kalimat pasif

Commented [WU38R37]: Sudah diubah menjadi pasif



(a) drop test through incremental face drop on 180 grit sandpaper

(b) scratch test

Fig. 3. Glass material characterization [13, 14].

Formatted Table

4 Analysis

The analysis was performed to evaluate their material structures including the presence of coating layer as well as their composition. Their structure will dictate the required process to remanufacture the phone casings to 'like-new' condition. The SEM observations in section 3 show that not all phone casings provide coating as a protection layer, as summarized in Table 4.

Table 4. Coating identification on mobile phone casing.

Brand	Model	Casing material	Coating	Thickness (m)
Apple	iPhone 5	Aluminum alloy	yes	4.628×10^{-6}
Xiaomi	Redmi 3	Aluminum alloy	yes	8.218×10^{-6} to 8.975×10^{-6}
Samsung	Galaxy S5	Polycarbonate	no	--
Samsung	Galaxy S6	Gorilla glass 4	no	--

In the case of physical damage on the coating part, the process of recovering it would take two stages, i.e. first is removing the coating and the next part is applying new one. However, those stages are not simple tasks because the remanufacturer should provide labors and materials, furthermore, the thickness of the coating should be consistent with certain tolerance to ensure the compatibility with the external accessories casing which increase the complexity of the process. Cost projection for those processes of cleaning and reconditioning is ~~quite~~ considerably high. As for the plastic casing, it is not feasible to recover the phone casing since replacing the damaged casing with the new casing would be much cheaper and manageable. Therefore, recovering or reconditioning plastic phone casing is not an option. As with glass casing, the literature study shows that it is not possible to recover a damaged glass phone class, since the process of manufacturing the casing cannot be made partially. However, considering the improvement in the latest series of gorilla glass, it seems that the probability to reuse the glass phone casing series 5 is high. It is most likely that the gorilla glass is still in a good condition when the product is collected for remanufacturing. Therefore, a remanufacturing is only possible when the glass casing s still in a good condition, with ~~no~~ no deep scratch or cracks.

Commented [KH39]: considerably

The analysis shows that remanufacturing of mobile phone casing is very limited. However, it does not mean that remanufacturing a mobile phone is not possible. It can be conducted when the other parts of mobile phone is recoverable, as follows:

(i) Plastic casing: the casing can be replaced by a new one with low cost

(ii) Aluminum casing: the phone casing can be remanufactured when the physical damage is minimal and can be recovered by thin coating

(iii) Glass casing: the phone casing can be remanufactured when it is in a good condition.

5 Conclusion

In carrying out remanufacturing casing for mobile phones, it is necessary to study its materials structure, composition, and damaged condition. Mobile phone casings from plastic, mainly made from polycarbonate and are varied in their texture, colour, and thickness from one brand to another depending on the design and price setting. As with mobile phones using glass materials for their casings, their casings are mainly made of Corning Gorilla glass. It is concluded that mobile phone casings are not suitable for remanufacturing due to the required remanufacturing work will be needed several stages of repair. As a result, the cost of remanufacturing may surpasses the price of new casings available in the market. This, therefore, makes remanufacturing become impractical to implement . However, considering the current practices by Apple and a refurbishing company in Malaysia, it is possible to recover mobile phone under refurbishment. Therefore, it initiates research toward improving the feasibility of refurbished mobile phone casings through material characterization.

References

1. C. Baldé, F. Wang, R. Kuehr, J. Huisman. *The Global E-Waste Monitor 2014*. Bonn: United Nations University (2015). p.8-24 https://i.unu.edu/media/unu.edu/news/52624/UNU-1stGlobal-E-Waste-Monitor-2014-small.pdf
2. C. Franke, B. Basdere, M. Ciupek, S. Seliger. Omega, **34**,6:562–570(2006). https://econpapers.repec.org/article/eeejomega/v_3a34_3ay_3a2006_3ai_3a6_3ap_3a562-570.htm
3. B. Tong. *Research on the cell phone remanufacturing and reselling*. [Thesis] Erasmus University Rotterdam (2006). p.18-42 https://www.maritimeeconomics.com/research/mel-thesis-library/
4. P. Rathore, S. Kota, A. Chakrabarti. J. Clean. Prod, **19**,15:1709–1722(2011). https://www.sciencedirect.com/science/article/pii/S0959652611002277
5. J. Quariguasi-Frota-Neto, J. Bloemhof, Production and Operations Management, **21**,1:101-114(2012).

   https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1937-5956.2011.01234.x

   ~~V.D.R.J Guide, V. Jayaraman, J.D. Linton. J. Oper. Manag, **21**,3:259–279(2003).~~
6. K. Xing, M. Belusko, L. Luong, K. Abhary. Int. J. Adv. Manuf. Tech, **35**,1:1–14(2007). https://link.springer.com/article/10.1007/s00170-006-0698-9
7. M. Kwak, H. Kim. J. Mech. Design, **135**,1:1–10(2013). http://mechanicaldesign.asmedigitalcollection.asme.org/article.aspx?articleID=1674697

Commented [A44]: Mohon ditambahkan halaman

Commented [SSG45R44]: sudah ditambahkan

Commented [A46]: Mohon ditambahkan halaman

Commented [SSG47R46]: sudah ditambahkan

Commented [A48]: Mohon diberikan link dari referensi ini.

Commented [SSG49R48]: sekarang sudah tidak ada link-nya, mungkin karena sudah lama. tetapi saya ada softcopynya. Juga, di link yang saya tuliskan bisa ditemukan judul thesisnya (tahun 2006)

Commented [A50]: Reference maksimal tahun 2004. Mohon diganti

Commented [SSG51R50]: sudah diganti (nomer 5)

8. R.T. Lund, W.M. Hauser. *Remanufacturing – An american perspective*. Proceeding of 5th International Conference on Responsive Manufacturing – Green Manufacturing, (Ningbo, China, 2010). ICRM, **2010**:1-6(2010) https://ieeexplore.ieee.org/document/5629156
9. M. Charter, C. Gray. Int. J. Prod. Dev, **6**,3–4:375–392(2008). https://www.researchgate.net/publication/247834190_Remanufacturing_and_product_design
10. A. Ikeda. *Remanufacturing of automotive parts in Japanese market*. The 24th CIRP Conference on Life Cycle Engineering, (Kamakura, Japan 2017). Procedia CIRP **61**: 800-803(2017). https://www.sciencedirect.com/science/article/pii/S2212827116314330
11. J. Ho. A discussion on material choices in mobile [Online] from https://www.anandtech.com/show/7984/discussion-on-material-choices-in-mobile (2014) [Accessed on 23 February 2019].
12. J. Purcher. Apple's Patent Pending 7000 Series Aluminum Invention used in the new iPhone 6s comes to Light [Online] from https://www.patentlyapple.com/patently-apple/2015/12/apples-patent-pending-7000-series-aluminum-invention-used-in-the-new-iphone-6s-comes-to-light.html (2015) [Accessed on 23 February 2019].
13. Corning Inc. *Corning Gorilla Glass 6*. [Online] from https://www.corning.com/content/dam/corning/microsites/csm/gorillaglass/PI_Sheets/Corning_Gorilla_Glass_6_PI_Sheet.pdf (2018) [Accessed on 23 February 2019].
14. Corning Inc. *Corning Gorilla Glass 5*. [Online] from https://www.corning.com/content/dam/corning/microsites/csm/gorillaglass/PI_Sheets/Corning%20Gorilla%20Glass%205_PI%20Sheet_Rev_C.pdf (2018) [Accessed on 21 May 2018].
15. Corning Inc. *Corning Gorilla Glass 4*. [Online] from https://www.corning.com/content/dam/corning/microsites/csm/gorillaglass/PI_Sheets/CGG_PI_Sheet_Gorilla%20Glass%204.pdf (2015) [Accessed on 21 May 2018]

UNIVERSITAS KRISTEN PETRA

Juliana Anggono <julianaa@petra.ac.id>

Jurnal ICAMME paper 66 Revisi

ma'ruf Nurwantara <makrufpambudinurwantara@gmail.com>
To: Juliana Anggono <julianaa@petra.ac.id>

Sat, Jul 20, 2019 at 1:17 AM

Baik ibu. Terimakasih banyak. Akan kami perbaiki kembali.

Regards
Ma'ruf Nurwantara

[Quoted text hidden]

> [Quoted text hidden]