



## DAFTAR PUSTAKA

- Agarwal, R. (2022). The personal protective equipment fabricated via 3D printing technology during COVID-19. *Annals of 3D Printed Medicine*, 5, 100042. <https://doi.org/10.1016/j.stlm.2021.100042>
- Al-Ekrish, A. A. (2012). Effect of exposure time on the accuracy and reliability of cone beam computed tomography in the assessment of dental implant site dimensions in dry skulls. *Saudi Dental Journal*, 24(3–4), 127–134. <https://doi.org/10.1016/j.sdentj.2012.05.001>
- Alghounaim, M., Almazedi, S., Al Youha, S., Papenburg, J., Alowaish, O., AbdulHussain, G., Al-Shemali, R., Albuloushi, A., Alzabin, S., Al-Wogayan, K., Al-Mutawa, Y., & Al-Sabah, S. (2020). Low-Cost Polyester-Tipped Three-Dimensionally Printed Nasopharyngeal Swab for the Detection of Severe Acute Respiratory Syndrome-Related Coronavirus 2 (SARS-CoV-2). 58(11), 1–9.
- Allen, N. S. (1996). Photoinitiators for UV and visible curing of coatings: Mechanisms and properties. *Journal of Photochemistry and Photobiology A: Chemistry*, 100(1–3), 101–107. [https://doi.org/10.1016/S1010-6030\(96\)04426-7](https://doi.org/10.1016/S1010-6030(96)04426-7)
- Ambrosio, D., Gabrion, X., Malécot, P., Amiot, F., & Thibaud, S. (2020). Influence of manufacturing parameters on the mechanical properties of projection stereolithography-manufactured specimens. *International Journal of Advanced Manufacturing Technology*, 106(1–2), 265–277. <https://doi.org/10.1007/s00170-019-04415-5>
- Andjela, L., Abdurahmanovich, V. M., Vladimirovna, S. N., Mikhailovna, G. I., Yurievich, D. D., & Alekseevna, M. Y. (2022). A review on Vat Photopolymerization 3D-printing processes for dental application. *Dental Materials*, 38(11), e284–e296. <https://doi.org/10.1016/j.dental.2022.09.005>
- Anycubic. (n.d.-a). *User Manual ANYCUBIC Photon Ultra*. Shenzhen Anycubic Technology Co., Ltd.
- Anycubic. (n.d.-b). *User Manual Anycubic Wash and Cure 2.0*.
- Arjunan, A., Zahid, S., Baroutaji, A., & Robinson, J. (2021). 3D printed auxetic nasopharyngeal swabs for COVID-19 sample collection. *Journal of the Mechanical Behavior of Biomedical Materials*, 114(October 2020), 104175. <https://doi.org/10.1016/j.jmbbm.2020.104175>
- Arnold, C., Monsees, D., Hey, J., & Schweyen, R. (2019). Surface quality of 3D-printed models as a function of various printing parameters. *Materials*, 12(12), 1–15. <https://doi.org/10.3390/ma12121970>
- ASME International. (2020). *Surface Texture (Surface Roughness, Waviness, and Lay)*. ASME International.
- Bae, C. J., Ramachandran, A., Chung, K., & Park, S. (2017). Ceramic stereolithography: Additive manufacturing for 3D complex ceramic structures. *Journal of the Korean Ceramic Society*, 54(6), 470–477. <https://doi.org/10.4191/kcers.2017.54.6.12>



KARAKTERISASI DAN EVALUASI PENGARUH PARAMETER CETAK DAN CURING TIME TERHADAP SIFAT MEKANIS, AKURASI, DIMENSI DAN KEKASARAN PERMUKAAN 3D-PRINTED NASOPHARYNGEAL SWAB UNTUK PENGUJIAN COVID-19

UNIVERSITAS  
GADJAH MADA

Ahmad Mamba'udin, Ir. Muhammad Akhsin Muflikhun, S.T., MSME., Ph.D.  
Universitas Gadjah Mada, 2023 | Diunduh dari <http://etd.repository.ugm.ac.id/>

- Bartolo, P. (2011). *Stereolithography: Materials, Processes and Applications*. Springer Science & Business Media.
- Beg, S., Almalki, W. H., Malik, A., Farhan, M., Aatif, M., Rahman, Z., Alruwaili, N. K., Alrobaian, M., Tarique, M., & Rahman, M. (2020). 3D printing for drug delivery and biomedical applications. *Drug Discovery Today*, 25(9), 1668–1681. <https://doi.org/10.1016/j.drudis.2020.07.007>
- Bennett, I., Bulterys, P. L., Chang, M., DeSimone, J. M., Fralick, J., Herring, M., Kabaria, H., Kong, C., Larson, B., Lu, O., Maxner, A., Meyer, E., Patterson, S., Pollack, S., Rolland, J., Schmidt, S., Seshadri, S., Swarup, K., Thomas, C., & Wert, R. Van. (2020). The Rapid Deployment of a 3D Printed ‘Latticed’ Nasopharyngeal Swab for COVID-19 Testing Made Using Digital Light Synthesis. *MedRxiv*, 1–9. <https://www.medrxiv.org/content/10.1101/2020.05.25.20112201v1>
- Boca, M. A., Sover, A., & Slătineanu, L. (2021). The Printing Parameters Effects on the Dimensional Accuracy of the Parts Made of Photosensitive Resin. *Macromolecular Symposia*, 396(1), 1–4. <https://doi.org/10.1002/masy.202000287>
- Callahan, C. J., Lee, R., Zulauf, K. E., Tamburello, L., Smith, K. P., Previtera, J., Cheng, A., Green, A., Azim, A. A., Yano, A., Doraiswami, N., Kirby, J. E., & Arnaout, R. A. (2020). Open development and clinical validation of multiple 3d-printed nasopharyngeal collection swabs: rapid resolution of a critical covid-19 testing bottleneck. *Journal of Clinical Microbiology*, 58(8). <https://doi.org/10.1128/JCM.00876-20>
- Callister Jr, W. D., & Rethwisch, D. G. (2018). *Materials Science and Engineering - An Introduction 10th Edition*.
- Chakraborty, B. C., & Ratna, D. (2020). Polymers for Vibration Damping Applications. In *News.Ge*. Matthew Deans.
- Chambers, A. R., Earl, J. S., Squires, C. A., & Suhot, M. A. (2006). The effect of voids on the flexural fatigue performance of unidirectional carbon fibre composites developed for wind turbine applications. *International Journal of Fatigue*, 28(10 SPEC. ISS.), 1389–1398. <https://doi.org/10.1016/j.ijfatigue.2006.02.033>
- Chapra, S. C., & Canale, R. P. (2010). Applied Numerical Methods for Chemical Engineers. In *Applied Numerical Methods for Chemical Engineers*. McGraw-Hill. <https://doi.org/10.1016/C2019-0-04646-8>
- Chen, Q., Zou, B., Lai, Q., Zhao, Y., & Zhu, K. (2022). Influence of irradiation parameters on the curing and interfacial tensile strength of HAP printed part fabricated by SLA-3D printing. *Journal of the European Ceramic Society*, 42(14), 6721–6732. <https://doi.org/10.1016/j.jeurceramsoc.2022.07.019>
- Chockalingam, K., Jawahar, N., & Chandrasekhar, U. (2006). Influence of layer thickness on mechanical properties in stereolithography. *Rapid Prototyping Journal*, 12(2), 106–113. <https://doi.org/10.1108/13552540610652456>
- Cox, J. L., & Koepsell, S. A. (2021). 3D-Printing to Address COVID-19 Testing Supply Shortages. *Lab Medicine*, 51(4), E45–E46. <https://doi.org/10.1093/LABMED/LMAA031>
- Danilo, M., Cardoso, R. M., Migliorini, F. L., Facure, M. H. M., Mercante, L. A.,



- Mattoso, L. H. C., & Correa, D. S. (2022). Trends in Analytical Chemistry Advances in 3D printed sensors for food analysis. *Trends in Analytical Chemistry*, 154, 116672. <https://doi.org/10.1016/j.trac.2022.116672>
- Decker, C. (1994). Photoinitiated curing of multifunctional monomers. *Acta Polymerica*, 45(5), 333–347. [http://doi.wiley.com/10.1002/actp.1994.010450501](http://doi.wiley.com/10.1002/actp.1994.010450501%0Apapers3://publicatio)
- Decker, S. J., Goldstein, T. A., Ford, J. M., Teng, M. N., Pugliese, R. S., Berry, G. J., Pettengill, M., Silbert, S., Hazelton, T. R., Wilson, J. W., Shine, K., Wang, Z. X., Hutchinson, M., Castagnaro, J., Bloom, O. E., Breining, D. A., Goldsmith, B. M., Sinnott, J. T., O'Donnell, D. G., ... Kim, K. (2021). 3-Dimensional Printed Alternative to the Standard Synthetic Flocked Nasopharyngeal Swabs Used for Coronavirus Disease 2019 Testing. *Clinical Infectious Diseases*, 73(9), E3027–E3032. <https://doi.org/10.1093/cid/ciaa1366>
- Derban, P., Negrea, R., Rominu, M., & Marsavina, L. (2021). Influence of the printing angle and load direction on flexure strength in 3d printed materials for provisional dental restorations. *Materials*, 14(12). <https://doi.org/10.3390/ma14123376>
- Dey, N. K., & Liou, F. W. (2013). *Scholars ' Mine Additive Manufacturing Laser Deposition of Ti - 6Al - 4V for Aerospace Repair Applications Additive Manufacturing Laser Deposition of Ti-6Al-4V for Aerospace Repair Applications*. 853–858.
- Dielemans, G., Lachmayer, L., Recker, T., Raatz, A., Lowke, D., & Gerke, M. (2022). *Cement and Concrete Research Additive Manufacturing using mobile robots : Opportunities and challenges for building construction*. 158(October 2021). <https://doi.org/10.1016/j.cemconres.2022.106772>
- Dzadz, Ł., & Pszczołkowski, B. (2020). Analysis of the influence of UV light exposure time on hardness and density properties of SLA models. *Technical Sciences*, 23(2020), 175–184. <https://doi.org/10.31648/ts.6119>
- Eren, T. N., Okte, N., Morlet-Savary, F., Fouassier, J. P., Lalevee, J., & Avci, D. (2016). One-component thioxanthone-based polymeric photoinitiators. *Journal of Polymer Science, Part A: Polymer Chemistry*, 54(20), 3370–3378. <https://doi.org/10.1002/pola.28227>
- Favero, C. S., English, J. D., Cozad, B. E., Wirthlin, J. O., Short, M. M., & Kasper, F. K. (2017). Effect of print layer height and printer type on the accuracy of 3-dimensional printed orthodontic models. *American Journal of Orthodontics and Dentofacial Orthopedics*, 152(4), 557–565. <https://doi.org/10.1016/j.ajodo.2017.06.012>
- Ford, J., Goldstein, T., Trahan, S., Neuwirth, A., Tatoris, K., & Decker, S. (2020). A 3D-printed nasopharyngeal swab for COVID-19 diagnostic testing. *3D Printing in Medicine*, 6(1), 1–7. <https://doi.org/10.1186/s41205-020-00076-3>
- Formlabs. (2022a). *Delamination (SLA)*. [https://support.formlabs.com/s/article/Delamination?language=en\\_US](https://support.formlabs.com/s/article/Delamination?language=en_US)
- Formlabs. (2022b). *Ragging*. [https://support.formlabs.com/s/article/Ragging?language=en\\_US](https://support.formlabs.com/s/article/Ragging?language=en_US)



- Fouassier, J. P. (1995). *Photoinitiation, photopolymerization and photocuring*. Hanser.
- Fouassier, J. P., & Lalevee, J. (2012). *Photoinitiators for Polymer Synthesis: Scope, Reactivity, and Efficiency*. John Wiley & Son.
- Frketic, J., Dickens, T., & Ramakrishnan, S. (2017). Automated manufacturing and processing of fiber-reinforced polymer (FRP) composites: An additive review of contemporary and modern techniques for advanced materials manufacturing. *Additive Manufacturing*, 14, 69–86. <https://doi.org/10.1016/j.addma.2017.01.003>
- Gallup, N., Pringle, A. M., Oberloier, S., Tanikella, N. G., & Pearce, J. M. (2020). Parametric nasopharyngeal swab for sampling COVID-19 and other respiratory viruses: Open source design, SLA 3-D printing and UV curing system. *HardwareX*, 8, e00135. <https://doi.org/10.1016/j.ohx.2020.e00135>
- Girod, S., Zahm, J. M., Plotkowski, C., Beck, G., & Puchelle, E. (1992). Role of the physicochemical properties of mucus in the protection of the respiratory epithelium. *The European Respiratory Journal*, 5(4), 477–487.
- Grindle, G. G., Strollo, P., Swiatkowski, R. A., Sonel, A., Kaplan, J., Eckstein, I., & Cooper, R. A. (2022). Rapid Deployment of Nasopharyngeal Test Swabs Within the US Department of Veterans Affairs. *Technology & Innovation*, 22(2), 189–197. <https://doi.org/10.21300/22.2.2021.8>
- Hada, T., Kanazawa, M., Iwaki, M., Arakida, T., Soeda, Y., Katheng, A., Otake, R., & Minakuchi, S. (2020). Effect of printing direction on the accuracy of 3D-printed dentures using stereolithography technology. *Materials*, 13(15), 1–12. <https://doi.org/10.3390/ma13153405>
- Hibbeler, R. C. (2011). *Mechanics of Materials*. 8th ed. New Jersey: Pearson Prentice Hall.
- Jindal, P., Juneja, M., Bajaj, D., Siena, F. L., & Breedon, P. (2020). Effects of post-curing conditions on mechanical properties of 3D printed clear dental aligners. *Rapid Prototyping Journal*, 26(8), 1337–1344. <https://doi.org/10.1108/RPJ-04-2019-0118>
- Kafle, A., Luis, E., Silwal, R., Pan, H. M., Shrestha, P. L., & Bastola, A. K. (2021). 3D / 4D Printing of Polymers : Fused Deposition Modelling ( FDM ), *Polymers*, 13, 1–37. <https://doi.org/10.3390>
- Kazemzadeh Farizhandi, A. A., Khalajabadi, S. Z., Krishnadoss, V., & Noshadi, I. (2020). Synthesized biocompatible and conductive ink for 3D printing of flexible electronics. *Journal of the Mechanical Behavior of Biomedical Materials*, 110(July), 103960. <https://doi.org/10.1016/j.jmbbm.2020.103960>
- Khudyakov, I. V. (2018). Fast photopolymerization of acrylate coatings : Achievements and problems. *Progress in Organic Coatings*, 121, 151–159. <https://doi.org/10.1016/j.porgcoat.2018.04.030>
- Ko, J., Bloomstein, R. D., Briss, D., Holland, J. N., Morsy, H. M., Kasper, F. K., & Huang, W. (2021). Effect of build angle and layer height on the accuracy of 3-dimensional printed dental models. *American Journal of Orthodontics and Dentofacial Orthopedics*, 160(3), 451-458.e2. <https://doi.org/10.1016/j.ajodo.2020.11.039>
- Komjaty, A., Wisznovszky (Muncut), E. S., & Culda, L. I. (2021). Study on the



- influence of technological parameters on 3D printing with sla technology. *MATEC Web of Conferences*, 343, 01003. <https://doi.org/10.1051/matecconf/202134301003>
- Kowsari, K., Zhang, B., Panjwani, S., Chen, Z., Hingorani, H., Akbari, S., Fang, N. X., & Ge, Q. (2018). Photopolymer formulation to minimize feature size, surface roughness, and stair-stepping in digital light processing-based three-dimensional printing. *Additive Manufacturing*, 24(October), 627–638. <https://doi.org/10.1016/j.addma.2018.10.037>
- Kurimoto, M., Manabe, Y., Mitsumoto, S., & Suzuoki, Y. (2021). Layer interface effects on dielectric breakdown strength of 3D printed rubber insulator using stereolithography. *Additive Manufacturing*, 46(March), 102069. <https://doi.org/10.1016/j.addma.2021.102069>
- Lai, S. K., Wang, Y. Y., Wirtz, D., & Hanes, J. (2009). Micro- and macrorheology of mucus. *Advanced Drug Delivery Reviews*, 61(2), 86–100. <https://doi.org/10.1016/j.addr.2008.09.012>
- Lesage, P., Dembinski, L., Lachat, R., & Roth, S. (2022). Mechanical characterization of 3D printed samples under vibration: Effect of printing orientation and comparison with subtractive manufacturing. *Results in Engineering*, 13(February). <https://doi.org/10.1016/j.rineng.2022.100372>
- Li, H., & Fan, W. (2020). *Three-dimensional printing : The potential technology widely used in medical fields*. March, 1–13. <https://doi.org/10.1002/jbm.a.36979>
- Lima, A. F., Salvador, M. V. O., Dressano, D., Saraceni, C. H. C., Gonçalves, L. S., Hadis, M., & Palin, W. M. (2019). Increased rates of photopolymerisation by ternary type II photoinitiator systems in dental resins. *Journal of the Mechanical Behavior of Biomedical Materials*, 98(April), 71–78. <https://doi.org/10.1016/j.jmbbm.2019.06.005>
- Madhavadas, V., Srivastava, D., Chadha, U., Raj, S. A., Thariq, M., Sultan, H., Shahar, F. S., & Shah, A. U. (2022). A review on metal additive manufacturing for intricately shaped aerospace components. *CIRP Journal of Manufacturing Science and Technology*, 39, 18–36. <https://doi.org/10.1016/j.cirpj.2022.07.005>
- Madžarević, M., & Ibrić, S. (2021). Evaluation of exposure time and visible light irradiation in LCD 3D printing of ibuprofen extended release tablets. *European Journal of Pharmaceutical Sciences*, 158(January). <https://doi.org/10.1016/j.ejps.2020.105688>
- Manapat, J. Z., Chen, Q., Ye, P., & Advincula, R. C. (2017). 3D Printing of Polymer Nanocomposites via Stereolithography. *Macromolecular Materials and Engineering*, 302(9), 1–13. <https://doi.org/10.1002/mame.201600553>
- Manoj, A., Bhuyan, M., Raj Banik, S., & Ravi Sankar, M. (2021). 3D printing of nasopharyngeal swabs for COVID-19 diagnose: Past and current trends. *Materials Today: Proceedings*, 44, 1361–1368. <https://doi.org/10.1016/j.matpr.2020.11.505>
- Marks, M., Millat-Martinez, P., Ouchi, D., Roberts, C. h., Alemany, A., Corbacho-Monné, M., Ubals, M., Tobias, A., Tebé, C., Ballana, E., Bassat, Q., Baro, B., Vall-Mayans, M., G-Beiras, C., Prat, N., Ara, J., Clotet, B., & Mitjà, O. (2021).



KARAKTERISASI DAN EVALUASI PENGARUH PARAMETER CETAK DAN CURING TIME TERHADAP SIFAT MEKANIS, AKURASI, DIMENSI DAN KEKASARAN PERMUKAAN 3D-PRINTED NASOPHARYNGEAL SWAB UNTUK PENGUJIAN COVID-19

UNIVERSITAS  
GADJAH MADA

Ahmad Mamba'udin, Ir. Muhammad Akhsin Muflikhun, S.T., MSME., Ph.D.

Universitas Gadjah Mada, 2023 | Diunduh dari <http://etd.repository.ugm.ac.id/>

- Transmission of COVID-19 in 282 clusters in Catalonia, Spain: a cohort study. *The Lancet Infectious Diseases*, 21(5), 629–636. [https://doi.org/10.1016/S1473-3099\(20\)30985-3](https://doi.org/10.1016/S1473-3099(20)30985-3)
- Marty, F. M., Chen, K., & Verrill, K. A. (2020). How to Obtain a Nasopharyngeal Swab Specimen. *New England Journal of Medicine*, 382(22), e76. <https://doi.org/10.1056/nejmcm2010260>
- McCarty, M. C., Chen, S. J., English, J. D., & Kasper, F. (2020). Effect of print orientation and duration of ultraviolet curing on the dimensional accuracy of a 3-dimensionally printed orthodontic clear aligner design. *American Journal of Orthodontics and Dentofacial Orthopedics*, 158(6), 889–897. <https://doi.org/10.1016/j.ajodo.2020.03.023>
- Melchels, F. P. W., Feijen, J., & Grijpma, D. W. (2010). Biomaterials A review on stereolithography and its applications in biomedical engineering. *Biomaterials*, 31(24), 6121–6130. <https://doi.org/10.1016/j.biomaterials.2010.04.050>
- Melnyk, L. A., & Oyewumi, M. O. (2021). Annals of 3D Printed Medicine Integration of 3D printing technology in pharmaceutical compounding : Progress , prospects , and challenges. *Annals of 3D Printed Medicine*, 4, 100035. <https://doi.org/10.1016/j.stlm.2021.100035>
- Montal, J. M., Pernas-Sánchez, J., & Varas, D. (2021). Experimental characterization framework for SLA additive manufacturing materials. *Polymers*, 13(7). <https://doi.org/10.3390/polym13071147>
- Montero, J., de Castro, E. F., Romano, B. de C., Nima, G., Shimokawa, C. A. K., & Giannini, M. (2022). Color alterations, flexural strength, and microhardness of 3D printed resins for fixed provisional restoration using different post-curing times. *Dental Materials*, 38(8), 1271–1282. <https://doi.org/10.1016/j.dental.2022.06.023>
- Mostafa, K. G., Nobes, D. S., & Qureshi, A. J. (2020). Investigation of Light-Induced Surface Roughness in Projection Micro-Stereolithography Additive Manufacturing (P $\mu$ SLA). *Procedia CIRP*, 92(ii), 187–193. <https://doi.org/10.1016/j.procir.2020.05.177>
- Mostafa, K., Nobes, D., & Qureshi, A. (2020). Investigation of Light-Induced Surface Roughness in Projection Micro-Stereolithography Additive Manufacturing (P $\mu$ SLA). *Procedia CIRP*, 187–193.
- Mukherji, S. K., & Castillo, M. (1998). Normal cross-sectional anatomy of the nasopharynx, oropharynx, and oral cavity. *Neuroimaging Clinics of North America*, 8(1), 211–218.
- Naeem, O. A., Bencharit, S., Yang, I. H., Stilianoudakis, S. C., Carrico, C., & Tüfekçi, E. (2022). Comparison of 3-dimensional printing technologies on the precision, trueness, and accuracy of printed retainers. *American Journal of Orthodontics and Dentofacial Orthopedics*, 161(4), 582–591. <https://doi.org/10.1016/j.ajodo.2021.03.016>
- Ngo, T. D., Kashani, A., Imbalzano, G., Nguyen, K. T. Q., & Hui, D. (2018). Additive manufacturing (3D printing): A review of materials, methods, applications and challenges. *Composites Part B: Engineering*, 143(February), 172–196. <https://doi.org/10.1016/j.compositesb.2018.02.012>



- Nomoto, R. (1997). The majority of light-activated composite materials contain the same catalyst system , and a light source developed for any one composite material may be equally suitable for any other material . However , differences in the composition of materials and i. *Dental Materials Journal*, 16(1), 60–73.
- Nowacki, B., Kowol, P., Kozioł, M., Olesik, P., Wieczorek, J., & Wacławiwak, K. (2021). Effect of post-process curing and washing time on mechanical properties of mslaprintouts. *Materials*, 14(17), 1–13. <https://doi.org/10.3390/ma14174856>
- Ocaña, I. R., & Molina, S. I. (2022). Cork photocurable resin composite for stereolithography (SLA): Influence of cork particle size on mechanical and thermal properties. *Additive Manufacturing*, 51(September 2021). <https://doi.org/10.1016/j.addma.2021.102586>
- Özdilli, Ö. (2021). Comparison of the Surface Quality of the Products Manufactured by the Plastic Injection Molding and SLA and FDM Method. *Uluslararası Mühendislik Arastirma ve Gelistirme Dergisi*, 428–437. <https://doi.org/10.29137/umagd.762942>
- Park, C., Choi, I., Roh, J., Lim, S. Y., Kim, S. H., Lee, J., & Yang, S. (2021). Evaluation of Applied Force during Nasopharyngeal Swab Sampling Using Handheld Sensorized Instrument. *Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS*, 2207–2210. <https://doi.org/10.1109/EMBC46164.2021.9629916>
- Patel, R., Babady, E., Theel, E., Storch, G., Pinsky, B., George, K., Smith, T., & Bertuzzi, S. (2020). Report from the American Society for Microbiology COVID-19 COVID-19. *MBio*, 11(2), 1–5.
- Pfaffinger, M. (2018). Hot Lithography - New Possibilities in Polymer 3D Printing. *Optik & Photonik*, 13(4), 99–101. <https://doi.org/10.1002/oppb.201870421>
- Quan, H., Zhang, T., Xu, H., Luo, S., Nie, J., & Zhu, X. (2020). Photo-curing 3D printing technique and its challenges. *Bioactive Materials*, 5(1), 110–115. <https://doi.org/10.1016/j.bioactmat.2019.12.003>
- Ranjan, R., Kumar, D., Kundu, M., & Chandra Moi, S. (2022). A critical review on Classification of materials used in 3D printing process. *Materials Today: Proceedings*. <https://doi.org/10.1016/j.matpr.2022.03.308>
- Ribas-Massonis, A., Cicujano, M., Duran, J., Besalú, E., & Poater, A. (2022). Free-Radical Photopolymerization for Curing Products for Refinish Coatings Market. *Polymers*, 14(14), 2856. <https://doi.org/10.3390/polym14142856>
- Rossini, G., Parrini, S., Castroflori, T., Deregbis, A., & Debernardi, C. L. (2016). Diagnostic accuracy and measurement sensitivity of digital models for orthodontic purposes: A systematic review. *American Journal of Orthodontics and Dentofacial Orthopedics*, 149(2), 161–170. <https://doi.org/10.1016/j.ajodo.2015.06.029>
- Rothon, H. A., & Byrareddy, S. N. (2020). The epidemiology and pathogenesis of coronavirus disease (COVID-19) outbreak. *Journal of Autoimmunity*, 109(February), 102433. <https://doi.org/10.1016/j.jaut.2020.102433>
- Sabbah, A., Romanos, G., & Delgado-Ruiz, R. (2022). Extended Post-Curing Light Exposure and Sandblasting Effects on Surface Hydrophobicity of 3D-Printed Denture Base Resin. *Prostheses*, 4(1), 80–90.



<https://doi.org/10.3390/prosthesis4010009>

Sangermano, M. (2019). Recent advances in cationic photopolymerization. *Journal of Photopolymer Science and Technology*, 32(2), 233–236.  
<https://doi.org/10.2494/photopolymer.32.233>

Seprianto, D., Sugiantoro, R., Siproni, Yahya, & Erwin, M. (2020). The Effect of Rectangular Parallel Key Manufacturing Process Parameters Made with Stereolithography DLP 3D Printer Technology Against Impact Strength. *Journal of Physics: Conference Series*, 1500(1). <https://doi.org/10.1088/1742-6596/1500/1/012028>

Shah, J., Snider, B., Clarke, T., Kozutsky, S., Lacki, M., & Hosseini, A. (2019). Large-scale 3D printers for additive manufacturing: design considerations and challenges. *International Journal of Advanced Manufacturing Technology*, 104(9–12), 3679–3693. <https://doi.org/10.1007/s00170-019-04074-6>

Shaukat, U., Rossegger, E., & Schlägl, S. (2022). A Review of Multi-Material 3D Printing of Functional Materials via Vat Photopolymerization. *Polymers*, 14(12). <https://doi.org/10.3390/polym14122449>

Shim, J. S., Kim, J. E., Jeong, S. H., Choi, Y. J., & Ryu, J. J. (2020). Printing accuracy, mechanical properties, surface characteristics, and microbial adhesion of 3D-printed resins with various printing orientations. *Journal of Prosthetic Dentistry*, 124(4), 468–475.  
<https://doi.org/10.1016/j.prosdent.2019.05.034>

Shrivastava, A. (2018). Plastic Properties and Testing. In *Introduction to Plastics Engineering*. <https://doi.org/10.1016/b978-0-323-39500-7.00003-4>

Singh, S., Aburashed, R., & Natale, G. (2022). CFD based analysis of 3D printed nasopharyngeal swabs for COVID-19 diagnostics. *Computer Methods and Programs in Biomedicine*, 223, 106977.  
<https://doi.org/10.1016/j.cmpb.2022.106977>

Singh, T., Kumar, S., & Sehgal, S. (2020). 3D printing of engineering materials: A state of the art review. *Materials Today: Proceedings*, 28, 1927–1931.  
<https://doi.org/10.1016/j.matpr.2020.05.334>

Sipani, V., & Scranton, A. B. (2004). Photopolymerization, Cationic. *Encyclopedia of Polymer Science and Technology*, 10, 6–11.  
<https://doi.org/10.1002/0471440264.pst491>

Soh, M. S., & Yap, A. U. J. (2004). Influence of curing modes on crosslink density in polymer structures. *Journal of Dentistry*, 32(4), 321–326.  
<https://doi.org/10.1016/j.jdent.2004.01.012>

Srivastava, M., Rathee, S., Patel, V., Kumar, A., & Koppad, P. G. (2022). A review of various materials for additive manufacturing: Recent trends and processing issues. *Journal of Materials Research and Technology*, 21, 2612–2641.  
<https://doi.org/https://doi.org/10.1016/j.jmrt.2022.10.015>

Starosolski, Z., Admane, P., Dunn, J., Kaziny, B., Huisman, T. A. G. M., & Annapragada, A. (2020). Design of 3D-printed nasopharyngeal swabs for children is enabled by radiologic imaging. *American Journal of Neuroradiology*, 41(12), 2345–2347. <https://doi.org/10.3174/ajnr.A6794>

Sun, Y., Mercader, A., & Lueth, T. C. (2020). Design of 3D-printable nasopharyngeal swabs in Matlab for COVID-19 testing. 2(September), 3–4.



- <https://doi.org/10.18416/AMMM.2020.2009007>
- Tay, J. K., Cross, G. B., Lee, C. K., Yan, B., Loh, J., Lim, Z. Y., Ngiam, N., Chee, J., Gan, S. W., Saraf, A., Chow, W. T. E., Goh, H. L., Siow, C. H., Lian, D. W. Q., Loh, W. S., Loh, K. S., Chow, V. T. K., Wang, D. Y., Fuh, J. Y. H., ... Allen, D. M. (2020). Design and clinical validation of a 3D-printed nasopharyngeal swab for COVID-19 testing. *MedRxiv*. <https://doi.org/10.1101/2020.06.18.20134791>
- Thomas, K. (2020). The latest obstacle to getting tested? A shortage of face masks and swabs. *New York Times*. <https://www.nytimes.com/2020/03/18/health/coronavirus-test-shortages-face-masks-swabs.html>
- Tino, R., Moore, R., Antoline, S., Ravi, P., Wake, N., Ionita, C. N., Morris, J. M., Decker, S. J., Sheikh, A., Rybicki, F. J., & Chepelev, L. L. (2020). COVID-19 and the role of 3D printing in medicine. *3D Printing in Medicine*, 6(1), 1–8. <https://doi.org/10.1186/s41205-020-00064-7>
- Tofail, S. A. M., Koumoulos, E. P., Bandyopadhyay, A., Bose, S., O'Donoghue, L., & Charitidis, C. (2018). Additive manufacturing: scientific and technological challenges, market uptake and opportunities. *Materials Today*, 21(1), 22–37. <https://doi.org/https://doi.org/10.1016/j.mattod.2017.07.001>
- Tooker, A., Moya, M. L., Wang, D. N., Freeman, D., Borucki, M., Wheeler, E., Larsen, G., Shusteff, M., Duoss, E. B., & Spadaccini, C. M. (2021). Performance of three-dimensional printed nasopharyngeal swabs for COVID-19 testing. *MRS Bulletin*, 46(9), 813–821. <https://doi.org/10.1557/s43577-021-00170-9>
- Unkovskiy, A., Bui, P. H. B., Schille, C., Geis-Gerstorfer, J., Huettig, F., & Spintzyk, S. (2018). Objects build orientation, positioning, and curing influence dimensional accuracy and flexural properties of stereolithographically printed resin. *Dental Materials*, 34(12), e324–e333. <https://doi.org/10.1016/j.dental.2018.09.011>
- van der Elst, L. A., Gokce Kurtoglu, M., Leffel, T., Zheng, M., & Gumennik, A. (2020). Rapid Fabrication of Sterile Medical Nasopharyngeal Swabs by Stereolithography for Widespread Testing in a Pandemic. *Advanced Engineering Materials*, 22(11). <https://doi.org/10.1002/adem.202000759>
- Vieira Magaldi, B., de Oliveira da Costa Maia Pinto, M., Thiré, R., & Araujo, A. C. (2018). Comparison of the porosity of scaffolds manufactured by two additive manufacturing technologies: SLA and FDM. <https://doi.org/10.26678/abcm.cobem2017.cob17-1460>
- Wang, X., Jiang, M., Zhou, Z., Gou, J., & Hui, D. (2017). 3D printing of polymer matrix composites: A review and prospective. *Composites Part B: Engineering*, 110, 442–458. <https://doi.org/10.1016/j.compositesb.2016.11.034>
- Wiedemann, B., Dusel, K. H., & Eschl, J. (1995). Investigation into the influence of material and process on part distortion. *Rapid Prototyping Journal*, 1(3), 17–22. <https://doi.org/10.1108/13552549510094232>
- Williams, E., Bond, K., Isles, N., Chong, B., Johnson, D., & Druce, J. (2020). Pandemic printing: a novel 3D-printed swab for detecting SARS-CoV-2. *The*



KARAKTERISASI DAN EVALUASI PENGARUH PARAMETER CETAK DAN CURING TIME TERHADAP SIFAT MEKANIS, AKURASI, DIMENSI DAN KEKASARAN PERMUKAAN 3D-PRINTED NASOPHARYNGEAL SWAB UNTUK PENGUJIAN COVID-19

UNIVERSITAS  
GADJAH MADA

Ahmad Mambaudin, Ir. Muhammad Akhsin Muflikhun, S.T., MSME., Ph.D.  
Universitas Gadjah Mada, 2023 | Diunduh dari <http://etd.repository.ugm.ac.id/>

*Medical Journal of Australia*, 213(6), 276–27.  
<https://doi.org/10.5694/mja2.50726>

Xiang, D., Xu, Y., Bai, W., & Lin, H. (2021). Dental zirconia fabricated by stereolithography: Accuracy, translucency and mechanical properties in different build orientations. *Ceramics International*, 47(20), 28837–28847.  
<https://doi.org/10.1016/j.ceramint.2021.07.044>

Xuan, H., & Decker, C. (1993). Photocrosslinking of acrylated natural rubber. *Journal of Polymer Science Part A: Polymer Chemistry*, 31(3), 769–780.  
<https://doi.org/10.1002/pola.1993.080310323>

Zakeri, S., Vippola, M., & Levänen, E. (2020). A comprehensive review of the photopolymerization of ceramic resins used in stereolithography. *Additive Manufacturing*, 35(February), 101177.  
<https://doi.org/10.1016/j.addma.2020.101177>