#HackThePandemic

Hospitals around the world are close to running out of face masks in the middle of the worst pandemic of XXI century! Our purpose as a company has always been related to make a positive impact and tackle #GlobalChallenges through #Innovation, #Nanotechnology and #AntimicrobialMaterials. Our purpose leads us to contribute to solve this problem in a low-cost, quick, and descentralized way through #DistributedManufacturing. We propose a #Reusable, #Customizable, #Monobloc, #Antimicrobial and #Antiviral #3Dprinted #FaceMask made with #Copper3D high quality nanocomposites #PLACTIVE and #MDflex.

Let's HACK this
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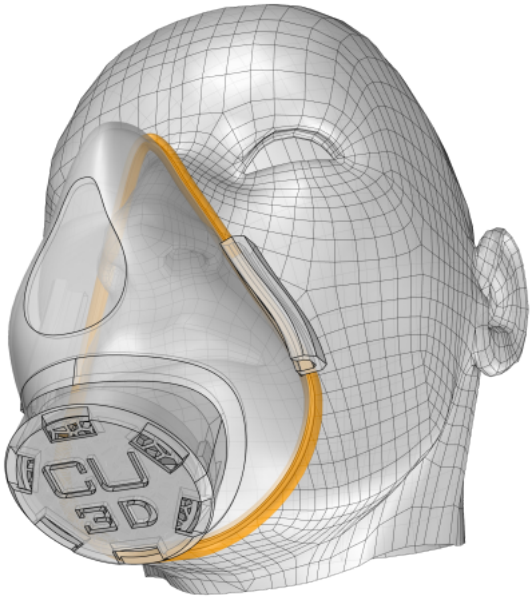
ABOUT NANOHACK 2.0

Our innovation is inspired by the scarcest products these days, face masks!

Basically, there is a breakdown in the global stock of face masks, and it is a basic necessity for general population in most countries. In many places the authorities have also recommended the use of these masks (or similar) on public transport. These masks, despite being effective, also have some problems like poor lateral fit, short lifecycle (about 8 hours), and have another even more serious problem. Respiratory viruses, specifically SARS-Cov-2 (COVID-19) can live up to 72 hours on different surfaces. This is a problem since using a conventional mask, at the end of the day we would have a high viral load trapped within millimeters of our nose and mouth, further exposing ourselves to these dangerous microbes. Our approach is to use active (antimicrobial) materials to address this problem, PLACTIVE® and MDflex®.



Download the NanoHack STL digital files here

Download STL
(https://copper3d.com/stl/g_facemask_nanohack.zip)

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THIS IS LAST RESORT DEVICE, NOT INTENDED TO BE A REGULAR PPE (PERSONAL PROTECTIVE EQUIPMENT) OR A N95 MASK. AS ANY 3D PRINTED DEVICE, YOU SHOULD POST-PROCESS, CLEAN, AND SEAL THE MASK IN ORDER TO USE PROPERLY. WE DON'T RECOMMEND TO PRINT FACE MASKS WITH REGULAR PLA, PET-G OR TPU MATERIALS, ANTIMICROBIAL/ACTIVE MATERIALS SHOULD BE THE CORRECT OPTION IN THIS CASE. THIS IS AN OPEN SOURCE FILE AND WE EXPECT YOUR COLLABORATION TO IMPROVE THIS DESIGN.

NANOHACK, THE OPEN SOURCE FACE MASK

NanoHack was inspired by a great global pandemic. The most radical innovations are born from crises, which is why NanoHack is a unique design.

ACTIVE MATERIALS

Manufactured with PLACTIVE® and MDflex®, innovative Nanocomposites developed by Copper3D, high quality PLA and TPU with a patented, scientifically validated and highly effective Nano-Copper based additive.

MONOBLOCK STRUCTURE

NanoHack 2.0 it's made of a monoblock PLACTIVE® structure to provide maximum protection against the external environment. Contrary to other concepts, NanoHack 2.0 is designed to be a strong and hermetic structure, sealed with a rim of Mdflex, an antimicrobial TPU.

REUSABLE & RECYCLABLE

You can use this mask any times you want. The increasing use of single-used surgical masks and N95 respirators will have a detrimental effect in the ecosystem. To prevent this detrimental effect in our environment, NanoHack will be made with recyclable material.

MODULAR FILTRATION SYSTEM

NanoHack incorporate a novel modular filtration system manufactured with a copper nanocomposite polymer. This novel active filtration system also includes 3 layers of non-woven propylene embedded in nano-copper, and can house third party filtration materials.

TECHNICAL CONSIDERATIONS ABOUT NANOHACK

NanoHack was conceived as an open source 3D printed face mask manufactured with active materials. These are some of the tecl

NanoHack Mask is a last resort device with the purpose of offering protection from airborne particles and prevent spreading liquid contaminating the airways. Published data1 has shown that the filtration materials used by NanoHack (non-woven polypropylene, the same material used in surgical masks) achieves a filtration efficiency of 96.4% for microorganisms of 1 micron and 89.5% for microorganisms of 0.02 microns[1].

According to the U.S. Food and Drug Administration (FDA), the design of surgical masks do not allow a complete protection from germs and other contaminants due to their loose fit[2]. In addition, surgical masks are single-used devices required to be safely disposed. The Centers for Disease Control and Prevention (CDC) recommends placing these items it in a plastic bag and put it in the trash, then wash your hands after handling the used mask[2]. Previous published research[3] has indicated that the high viral load remaining in surgical masks and respirators, can be a source of viral transmission both to the person wearing the mask or respirators and to others[3]. This may happen when healthcare workers touch their mask and then fail to wash their hands properly or when they dispose of the mask without proper safe disposal precautions[3]. In addition, pathogens shedding from surgical respirators onto patients in the operating room, increasing the risk of nosocomial infections[3]. Thus, NanoHack Mask uses a recyclable and biocompatible polymer containing a copper nanocomposite that has shown antimicrobial properties.

References

1.Anna Davies, et al. Testing the Efficacy of Homemade Masks: Would They Protect in an Influenza Pandemic? Disaster Medicine and Public Health Preparedness, Available on CJO 2013 doi:10.1017/dmp.2013.43.

2.Food and Drug Administration (FDA): https://www.fda.gov/medical-devices/personal-protective-equipment-infection-control/n95-respirators-and-surgical-masks-face-masks (https://www.fda.gov/medical-devices/personal-protective-equipment-infection-control/n95-respirators-and-surgical-masks-face-masks) Accessed March 20, 2020.

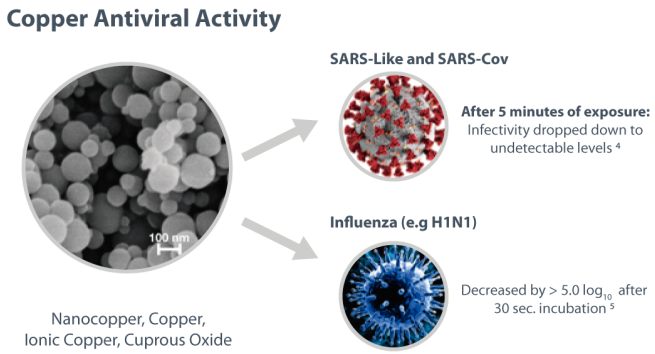
3.Borkow G, etal., (2010) A Novel Anti-Influenza Copper Oxide Containing Respiratory Face Mask. PLoS ONE 5(6): e11295. doi:10.1371/journal.pone.0011295.

ABOUT ANTIMICROBIAL ACTIVITY OF COPPER

Copper and Nano Copper inhibits the replication and propagation abilities of SARS- CoV[4], influenza[5] and other respiratory viruses, having a high antimicrobial (antiviral and antibacterial) potential and, as Copper can inactivate viruses as SARS-like and SARS- Cov[4], influenza virus[5], H1N1, and eliminates dangerous bacteria like Staphylococcus aureus, Escherichia coli, Listeria, among others[6], after a short period of exposure, Copper3D's PLACTIVE® and Mdflex® could be an effective and low-cost complementary strategy to help reducing transmission of several infectious diseases by limiting nosocomial infectious transmission.

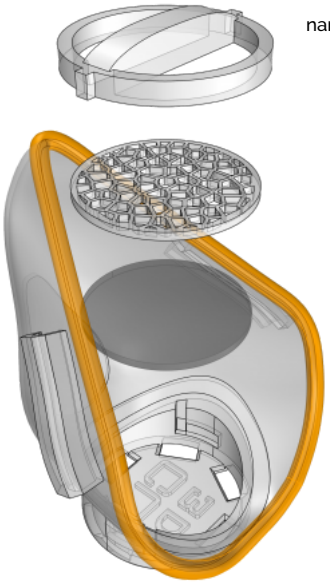
References

4. Han J, Chen L, Duan S, Yang Q, Yang M, Gao C, et al. Efficient and quick inactivation of SARS, coronavirus and other microbes exposed to the surfaces of some metal catalysts. Biomed Environ Sci BES, 2005.
5. Borkow G, Zhou SS, Page T, Gabbay J. A novel anti-influenza copper oxide containing respiratory face mask. PloS One. June 25, 2010;5(6):e11295.
6. Copper3D Inc. laboratory tests.



ABOUT THE FILTRATION SYSTEM OF NANOHACK

NanoHack was conceived as an active/antimicrobial 3D printed face mask manufactured with active materials. We will use active filters of non-woven polypropylene (3 layers) embedded in nanocopper to get an extra protection against microorganisms.



In the study by Borkow et al (2007)[7], a 2.5 cm filter was designed containing a 2 cm thick top layer of 500 mg of non-woven polypropylen impregnated with 5% copper oxide particles. This study had a control that was non-woven polypropylen copper-free as a control.
Diffusion of viruses through filters containing copper oxide resulted in a significant reduction in viral titers from 0.47 log10 to 4.6 log10 depending on the virus analyzed.

According to this study, it can be concluded that a non-woven fabric filter impregnated with copper oxide is capable of generating filtration of viruses of different types, including respiratory viruses, as can be seen in the attached table.

References

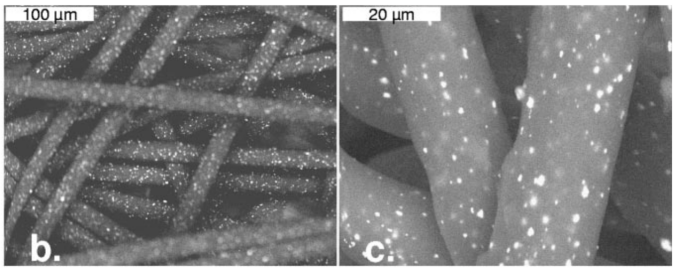
7. Borkow G, etal., (2007) Neutralizing Viruses in Suspensions by Copper Oxide-Based Filters. Antimicrobial Agents and Chemotherapy. p. 2605–2607.

TABLE 1. Reduction of infectious viral titers by copper oxide-containing filters

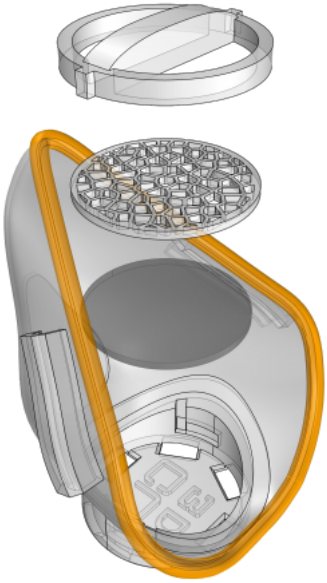
Virus	Viral strain	Viral family	Genome	E/NE[a]	Cells used in assay	Virus titer control[b]	Virus titer Cu filter[b]	Log_{10} reduction (mean ± SD)[c]	*P* value[d]
Rhinovirus 2	HGP	*Picornaviridae*	RNA	NE	HeLa Ohio-1	4.3/7/7	3.3/3/6	2 ± 1.7	0.2
Yellow fever virus	17D	*Flaviviridae*	RNA	E	Vero-76	6.3/6.3/5.9	5.7/4.7/4.8	1.1 ± 0.5	<0.05
Influenza A virus	Panama/ 2007/99 H3N2	*Orthomyxoviridae*	RNA	E	MDCK	7.5/7.5/6.8	6.7/5/4.8	1.77 ± 0.87	<0.001
Measles virus	Chicago	*Paramyxoviridae*	RNA	E	CV-1	3.67/3.67/3.67	0/0/0	≥3.67	<0.001
Respiratory syncytial virus	A2	*Paramyxoviridae*	RNA	E	MA-104	4/4/4	3/2/2.5	1.5 ± 0.5	<0.01
Parainfluenza virus 3	14702	*Paramyxoviridae*	RNA	E	MA-104	8/8/8	7.33/6.33/7	1.11 ± 0.5	<0.05
Punta Toro virus	Adames	*Bunyaviridae*	RNA	E	LLC-MK2	7/6.6/6.6	3.5/6/5.5	1.73 ± 1.55	0.09
Pichinde virus	AN 4763	*Arenaviridae*	RNA	E	BSC-1	7.5/7.6/7	4.5/5.6/6.9	1.7 ± 1.47	0.08
HIV-1	IIIB	*Retroviridae*	RNA	E	MT2	6/6.5/6	0.8/2.5/1.5	4.6 ± 0.6	0.001
Adenovirus type 1	Ad-HIVluc	*Adenoviridae*	DNA	NE	cMAGI	5/5/5.2	2.5/3.2/2.9	2.2 ± 0.36	0.001
Cytomegalovirus	AD169	*Herpesviridae*	DNA	E	Fibroblasts	6/6/6	2/1.5/1.6	4.3 ± 0.26	<0.001
Vaccinia virus	WR	*Poxviridae*	DNA	E	Vero-76	7.4/7.6/7.6	7.4/6.7/7.1	0.47 ± 0.45	0.095

[a] E, enveloped viruses; NE, nonenveloped viruses.
[b] Log_{10} PFU/ml for vaccinia virus; log_{10} $CCID_{50}$/ml for the other viruses.
[c] The log reduction was calculated as log_{10} $CCID_{50}$/ml of the titer obtained from the control filter minus log_{10} $CCID_{50}$/ml of the filter containing copper oxide. The values are the mean and standard deviation obtained in three separate experiments.
[d] *t* test between viral titers obtained after filtration in control filters not containing copper versus copper-containing filters.

In order to achieve optimum protection against the external environment, we recommend using a triple-layer non-woven polypropylene filter embedded in nano-copper developed by
The Copper Company (https://thecoppercompany.cl/).



Scanning electronic microscope pictures of the copper oxide-impregnated polypropylene fibers[7].



If you do not have access to this type of filter, the study by Anna Davies et al[1] analyze the filtering efficiency of different materials. See attached table:

Filtration Efficiency and Pressure Drop Across Materials Tested with Aerosols of *Bacillus atrophaeus* and Bacteriophage MS2 (30 L/min)[a]

Material	*B atrophaeus*		Bacteriophage MS2		Pressure Drop Across Fabric	
	Mean % Filtration Efficiency	SD	Mean % Filtration Efficiency	SD	Mean	SD
100% cotton T-shirt	69.42 (70.66)	10.53 (6.83)	50.85	16.81	4.29 (5.13)	0.07 (0.57)
Scarf	62.30	4.44	48.87	19.77	4.36	0.19
Tea towel	83.24 (96.71)	7.81 (8.73)	72.46	22.60	7.23 (12.10)	0.96 (0.17)
Pillowcase	61.28 (62.38)	4.91 (8.73)	57.13	10.55	3.88 (5.50)	0.03 (0.26)
Antimicrobial Pillowcase	65.62	7.64	68.90	7.44	6.11	0.35
Surgical mask	96.35	0.68	89.52	2.65	5.23	0.15
Vacuum cleaner bag	94.35	0.74	85.95	1.55	10.18	0.32
Cotton mix	74.60	11.17	70.24	0.08	6.18	0.48
Linen	60.00	11.18	61.67	2.41	4.50	0.19
Silk	58.00	2.75	54.32	29.49	4.57	0.31

[a] Numbers in parentheses refer to the results from 2 layers of fabric.

CLAIMS ABOUT NANOHACK:

The purpose of the NanoMask is to offer the general population a degree of protection against airborne particles and to prevent the spread of liquid aerosols that could contaminate the airways.

- It is not an N95 mask. It is a face mask and should not be considered as a PPE.
- If you are a healthcare professional, you should use it as a last resort device: you cannot manipulate airway such as intubation, mechanical ventilation, fiberoptic bronchoscopy and similar procedures.
- You can use it in common spaces.
- It should be used for a maximum of 8 hours and change the non-woven filter once a day. After handling the active filter, you should wash your hands and follow precautions as recommended by the health authority.
- Nanohack is a polymer based device, we recommend using PLACTIVE® (PLA based material) for the monoblock structure and MDflex® (TPU based material) to print the outer rim. With this setup, you can have a comfortable mask with a good seal.
- We understand that there may eventually be complex access to MDflex® in some parts of the world. This is why we have released a version with an integrated rim into the monoblock structure. With this solution you can obtain a structure that fits properly but that **must be complemented with some additional sealant and hypoallergenic cushioned tapes** for nose and cheeks, especially if it is going to be used for long periods of time.
- Keep in mind also that if you leave the elastic bands very tight it can hurt you, we don't want the use of NanoHack to be counterproductive or cause you discomfort.
- The NanoHack was designed to fit a 12 cm height face very well, measured from the tip of the chin to the ocular plane, a horizontal line that passes just between the eyes, and a distance between cheekbones (measured straight above the nose) also 12 cm.
- We understand that all faces are different. If your face is smaller or larger than these measurements, we suggest rescaling the model by 5% or 10% so that there is a perfect fit to your face.

CLEANING CONSIDERATIONS

1. Washing: Wash the equipment with soap (e.g. liquid dish soap) and clean water.
2. Rinsing: Rinse the equipment completely with clean water.
3. Disinfect: Disinfect the equipment to inactivate any remaining pathogens. Use chemical disinfection if plastic part cannot tolerate 80°C. Different countries have different disinfection protocols. Here are the most accessible chemical germicides and methods:

3.1. Method 1: Alcohol is effective against influenza virus. Ethyl alcohol (70%) is a powerful broad-spectrum
germicide and is considered generally superior to isopropyl alcohol. Since alcohol is flammable, limit its use as a surface disinfectant to small surface-areas and use it in well-ventilated spaces only. Prolonged and repeated use of alcohol as a disinfectant can also cause discoloration, swelling, hardening and cracking of rubber and certain plastics.

3.2. Method 2: Most household bleach solutions contain 5% sodium hypochlorite (50, 000 parts per million available chlorine). Recommended dilution: 1:100 dilution of 5% sodium hypochlorite is the usual recommendation. Use 1-part bleach to 99 parts cold tap water (1:100 dilution) for disinfection of surfaces. Adjust ratio of bleach to water as needed to achieve appropriate concentration of sodium hypochlorite. For example, for bleach preparations containing 2.5% sodium hypochlorite, use twice as much bleach (i.e. 2 parts bleach to 98 parts water).

4. Rinsing: If using chemical disinfection, rinse with sterile or clean water (i.e. water boiled for 5 minutes and cooled). Sterile water is preferred for rinsing off residual liquid chemical disinfectant from a respiratory device that has been chemically disinfected for reuse, because tap or distilled water may harbor microorganisms that can cause pneumonia. However, when rinsing with sterile water is not feasible, instead, rinse with tap water or filtered water (i.e. water passed through a 0.2 µ filter). Disinfection by immersion is recommended with a contact time of 30 minutes.
5. Dry equipment: Follow the previous step by an alcohol rinse and forced-air drying.
6. Store: Store equipment dry in closed packages.

1.Infection Prevention and Control of Epidemic- and Pandemic-Prone Acute Respiratory Infections in Health Care. Geneva: World Health Organization; 2014. Annex I, Cleaning and disinfection of respiratory equipment. Available from: https://www.ncbi.nlm.nih.gov/books/NBK214361

INTERNATIONAL PARTNERS

#HackThePandemic is an international collaborative effort of partner companies, organizations, and friends. People from all over the world would like to thank you guys! Keep on hacking this pandemic!

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