

## Preparation of executive files for hybrid 3D printing technology using extrusion of Polymer and Metal materials

### Entry

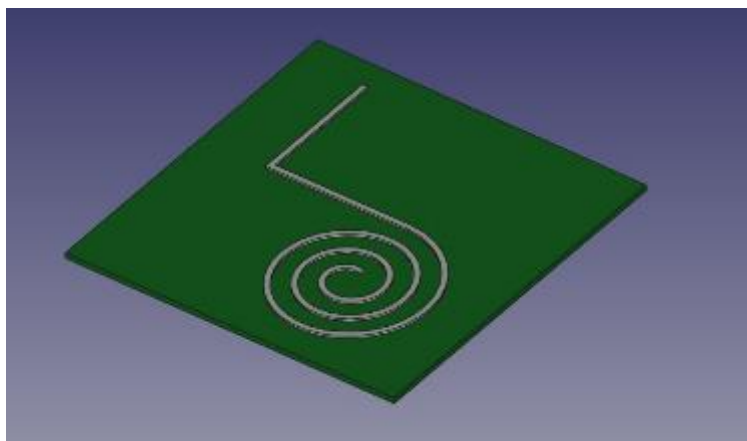
Programs that generate paths of the so-called Slicers allow the user to program the movements of the printer head based on the supplied 3D model. In the program, the 3D geometry, defined by means of a triangle mesh, is converted into a machine code in the gcode format, which is then transferred to the 3D printer. This report presents the possibilities of using the Simplify3D v5.0.0 software to prepare printing paths in hybrid 3D printing technology using extrusion of polymer and metal materials.

### Program usage strategy

In photo no. 1, two 3D models prepared with a CAD program are visible. The green model represents a substrate made of thermoplastic material, and the gray model represents a path made of a low-melting metal alloy.

Each time, in order to properly prepare the printing path, separate 3D models should be prepared for components printed from polymers and those made of low-melting metals.

The dimensions of the models must be selected taking into account the machine on which they will



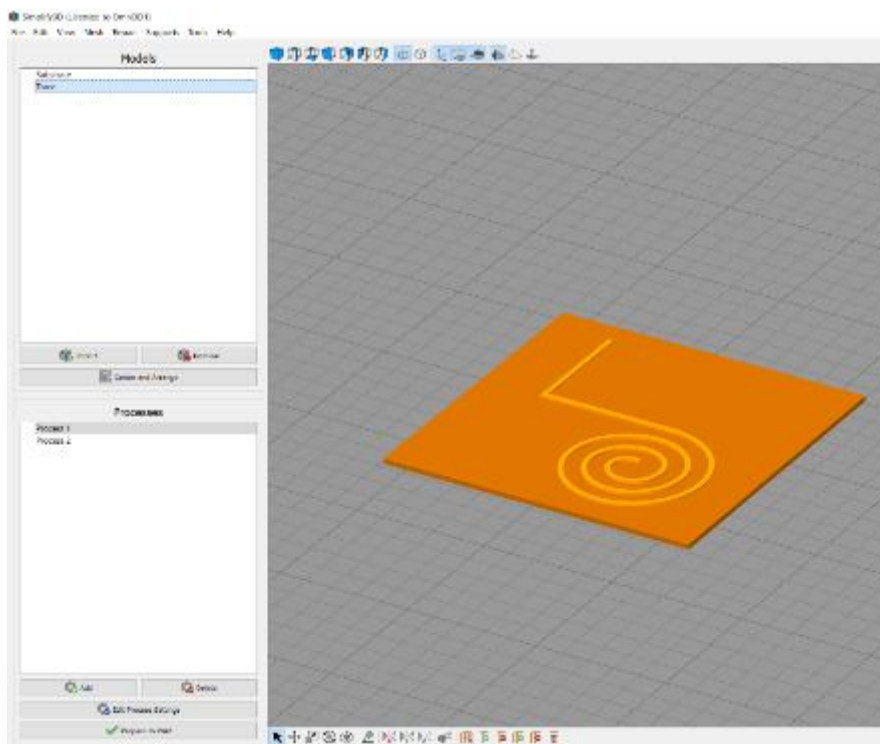
Zdjęcie 1 Wizualizacja modeli 3D wykonanych w programie CAD

be made. Otherwise, the created models will not be properly interpreted by the program that generates the machine code.

For example, for the Omni3D Factory 2.0 NET printer, the maximum print dimensions are 500x500x570mm in the X, Y and Z axes, respectively. The minimum wall thickness of the model made of polymer should not be less than 0.4mm, which corresponds to the diameter of the nozzle extruding the material. The minimum thickness of metal elements will correspond to the width of a single applied path defined in the course of the project.

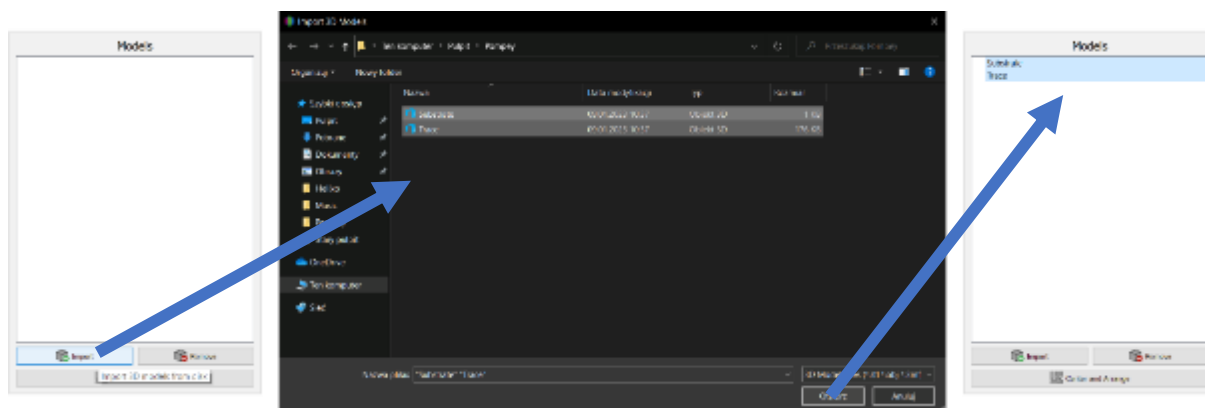
Models from a CAD program should be exported in a format that is supported by the Simplify3D program, i.e. STL, 3MF or OBJ.

After transferring the models to the Simplify3D slicer, the user can assign the printhead to a specific model, thus programming the production of a multi-material product.

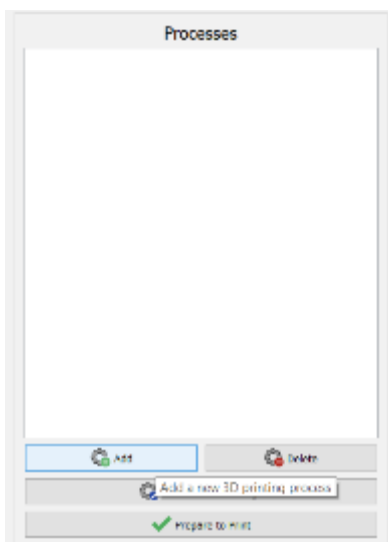


Zdjęcie 2 Okno programu Simplify3D

In order to import models to the program, left-click on the **Import button** (Photo 3)



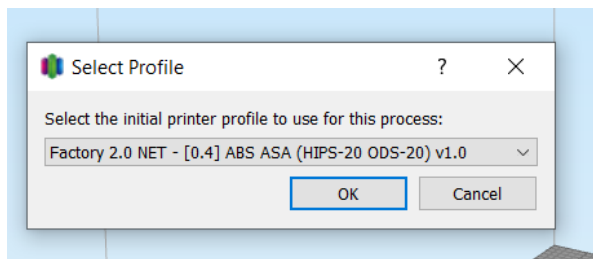
Zdjęcie 3 Procedura importowania modeli



Zdjęcie 4 Obszar procesów

After importing the models, two processes should be added by left-clicking the **Add** field in the **Processes** area (Photo 4).

Then the profile selection window will appear (Picture 5). We click

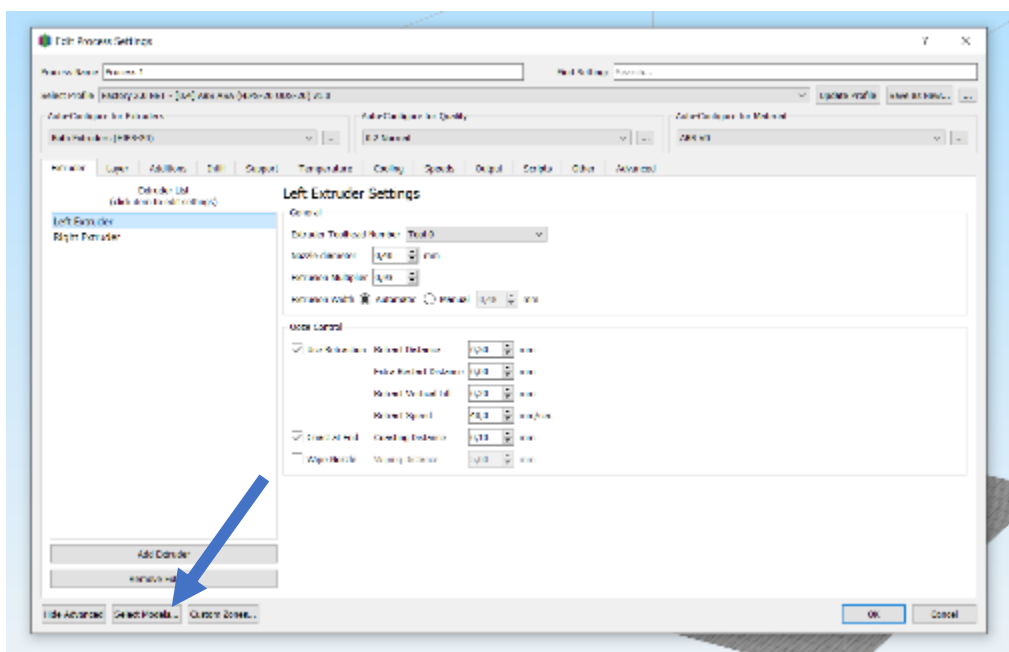


Zdjęcie 5 Okno wyboru profilu druku

OK.

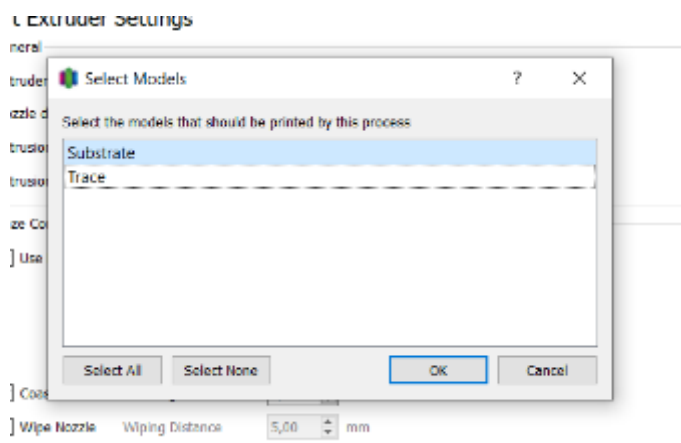
After confirming, the process editing window appears (Picture 6).

By clicking on the **Select Models...** field, you can select which model is to be printed according to the settings of the given process.



Zdjęcie 6 Okno edycji procesu z zaznaczonym polem **Select Models**

By clicking the left mouse button on the model name (Picture 7) you can select or deselect it. By

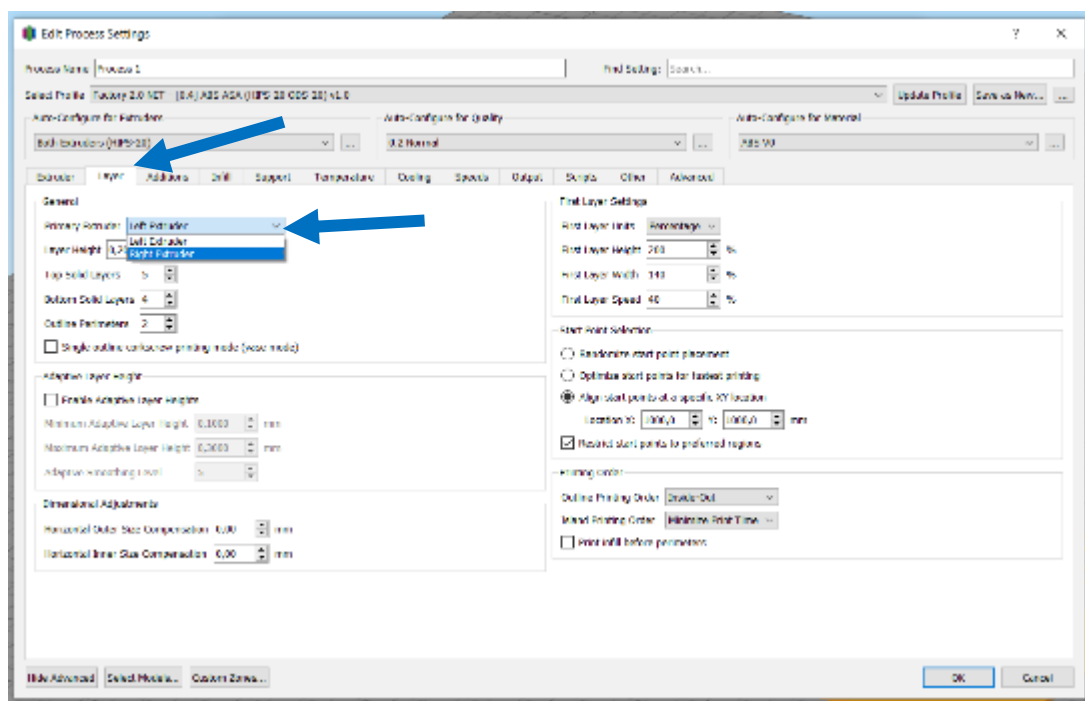


Zdjęcie 8 Okno Select Models

default, all model names are selected, i.e. the background behind the model name is blue, which means that the program will prepare commands for the printer for all models according to the process that is currently being edited.

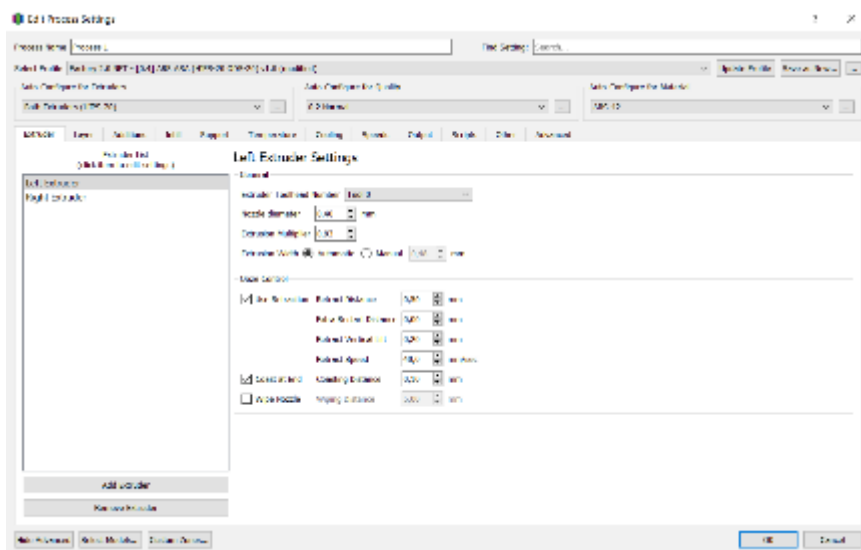
By deselecting a model by right-clicking on its name, the user makes it not considered by the process. The background color of such a model will change from blue to white. In this way, it is possible to prepare several processes assigned to different models. After making your selection, you can close the window by clicking on the OK field.

If the user wants to make a given model using a second hotend, in the next step he must go to the **Layer tab** and select **the Left Extruder** or **Right Extruder** option from **the Primary Extruder drop-down menu** (Photo 8). Do the same in the **Infill tab**, thus selecting which head will perform the filling.

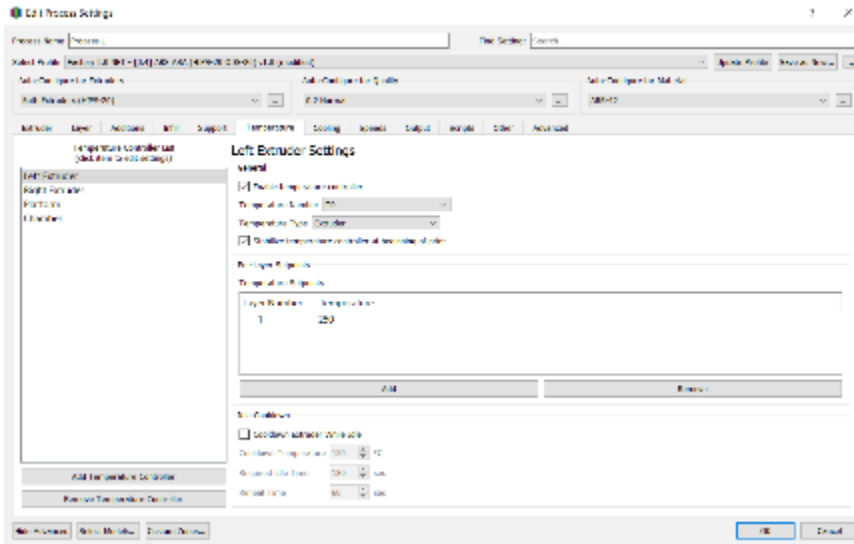


Zdjęcie 7 Wybór głowicy drukującej

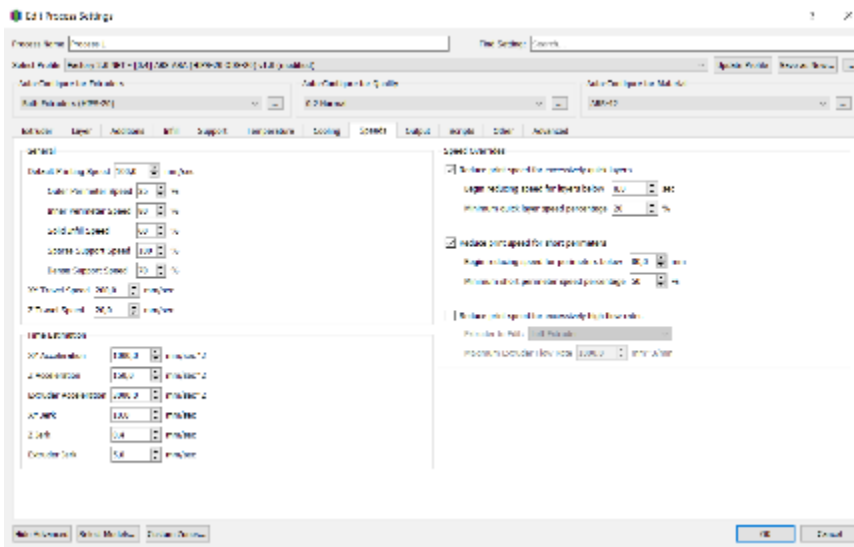
In addition to assigning the hotend to a given element of the model, it is also possible to modify the process parameters, e.g. path width, carriage speed or hotend temperature.



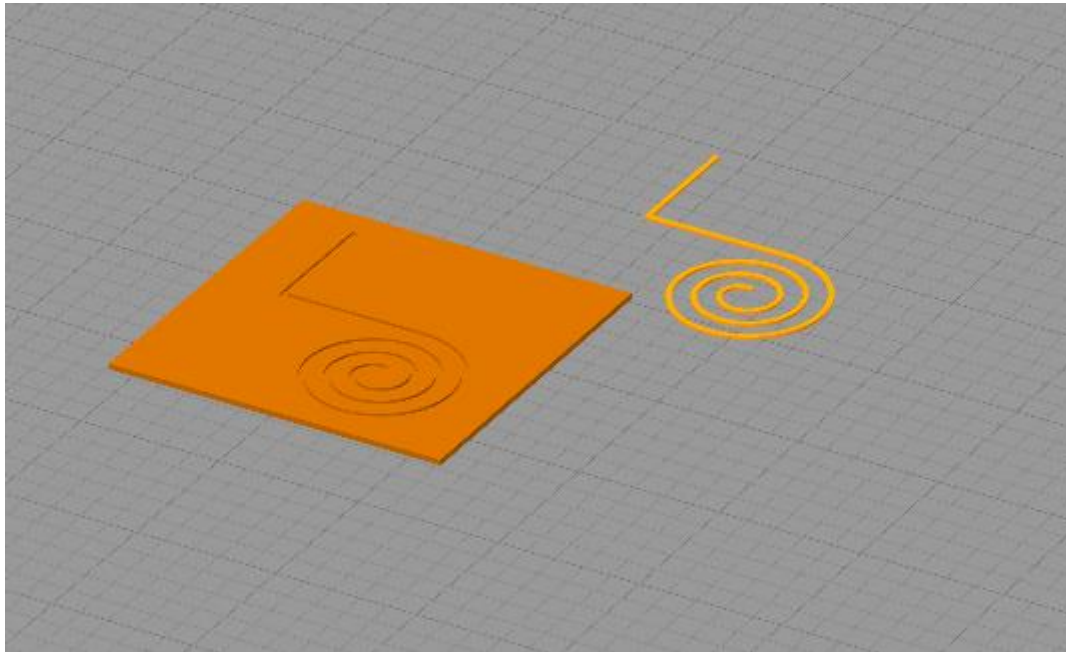
Zdjęcie 9 Okno ustawień procesu druku - Ekstruder



Zdjęcie 10 Okno ustawień procesu druku - Temperatura



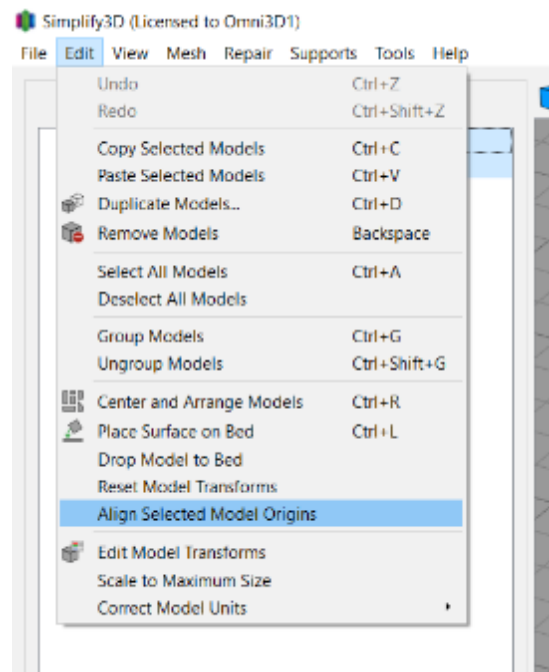
Zdjęcie 11 Okno ustawień procesu druku - Szybkości



Zdjęcie 12 Przykład niepożądanego modeli na platformie roboczej

You also need to make sure that the models are properly positioned relative to each other in space.

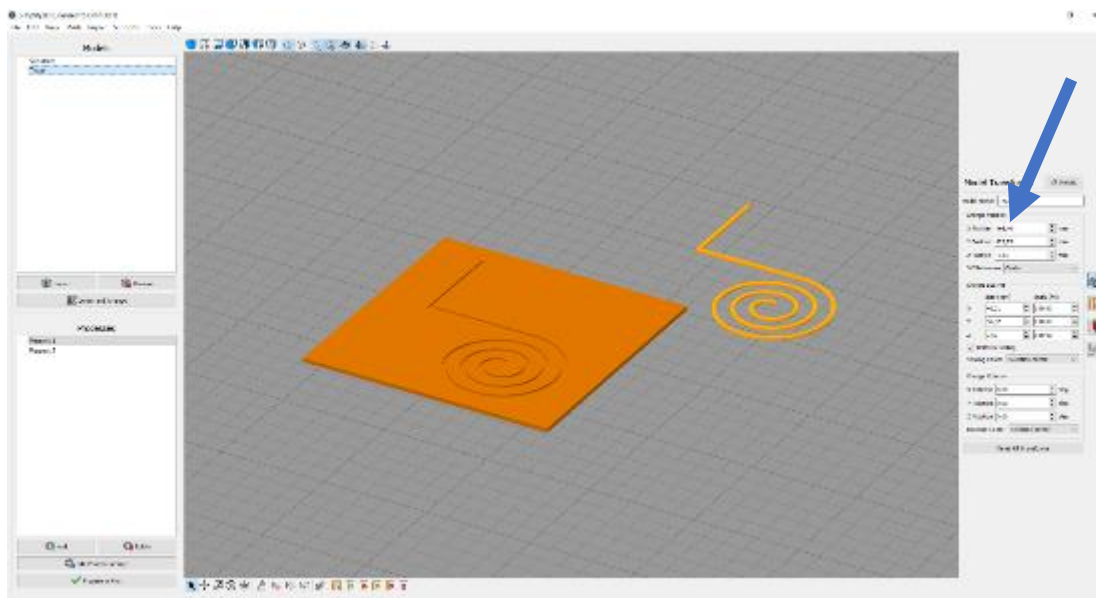
**Align option Selected Model Origins** from the **Edit tab** (Photo 13) allows you to restore the arrangement of models in space from the CAD program.



Zdjęcie 13 Umieszczanie modeli w oryginalnej orientacji.

If the position of the models on the build platform is still incorrect, it will be necessary to correct their position manually.

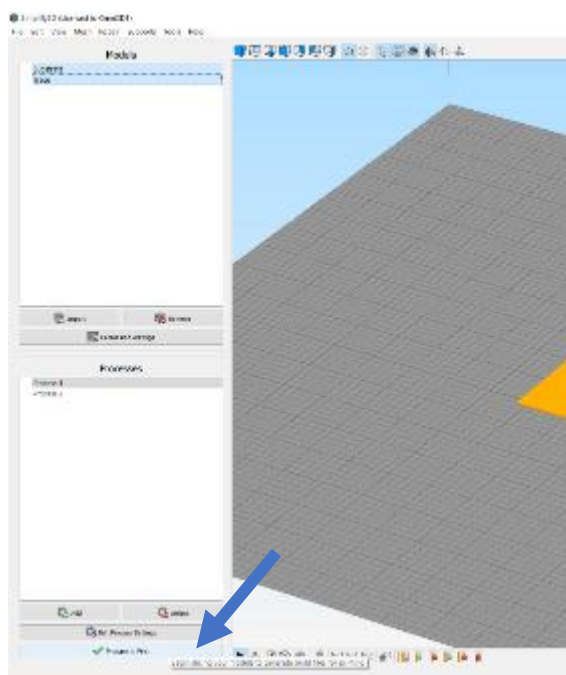
After double-clicking with the left mouse button on the model you want to move, a new window will appear on the right side of the screen (Picture 14). By changing the value of the distance between the model coordinate system and the working platform, it is possible to freely move and rotate the model along the XYZ axes.



Zdjęcie 14 Manualna korekcja położenia modeli.

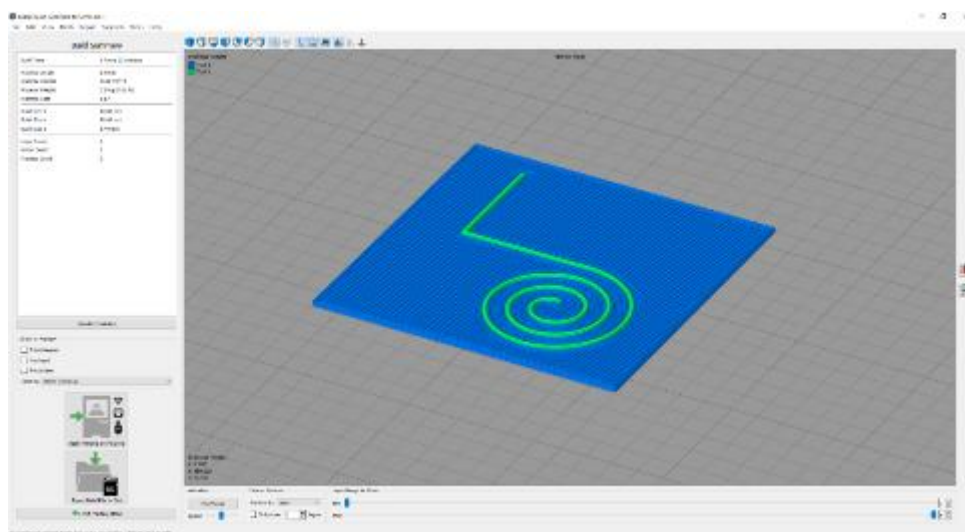
After selecting the appropriate process parameters and arranging the models on the work table, you can proceed to the generation of the machine code.

After left-clicking the **Prepare to Print** field, the program will display the visualization of the generated paths.



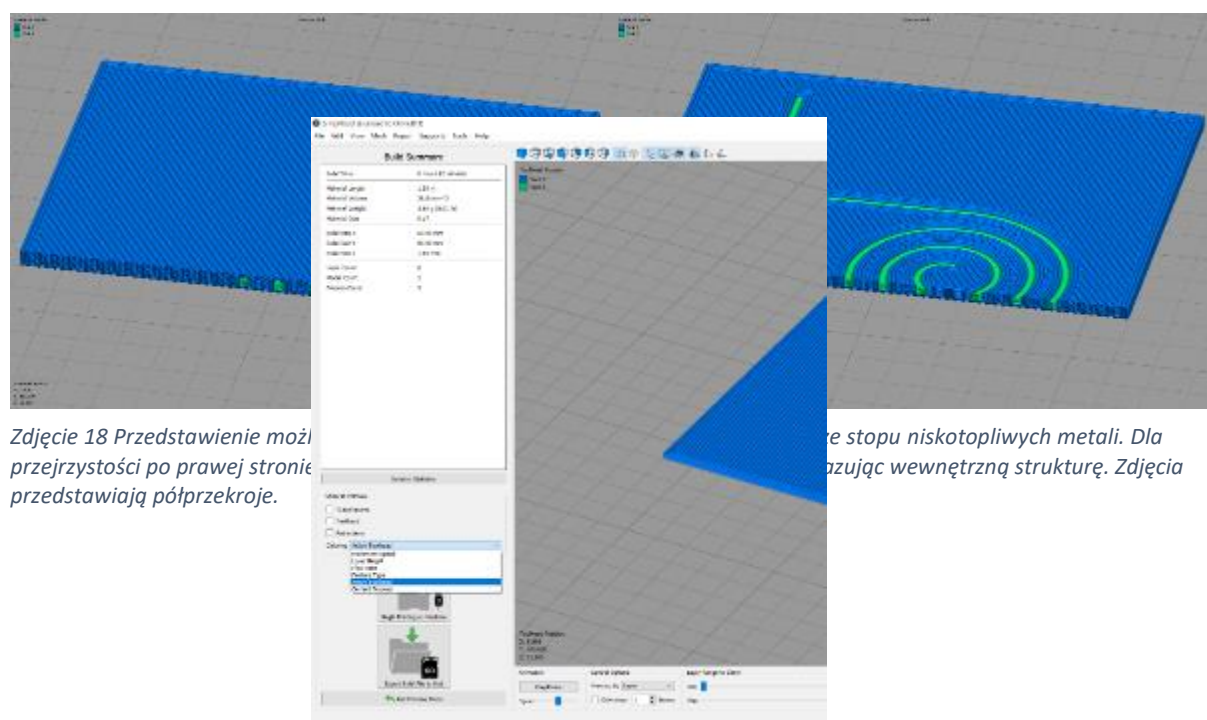
Zdjęcie 15 Generowanie kodu maszynowego gcode





Zdjęcie 16 Wizualizacja ścieżek.

Photo number 16 shows a visual interpretation of the machine code generated by the program.



Zdjęcie 18 Przedstawienie możliwości przejrzystości po prawej stronie przedstawiają półprzekroje.

...e stopu niskotopliwych metali. Dla ...azując wewnętrzną strukturę. Zdjęcia

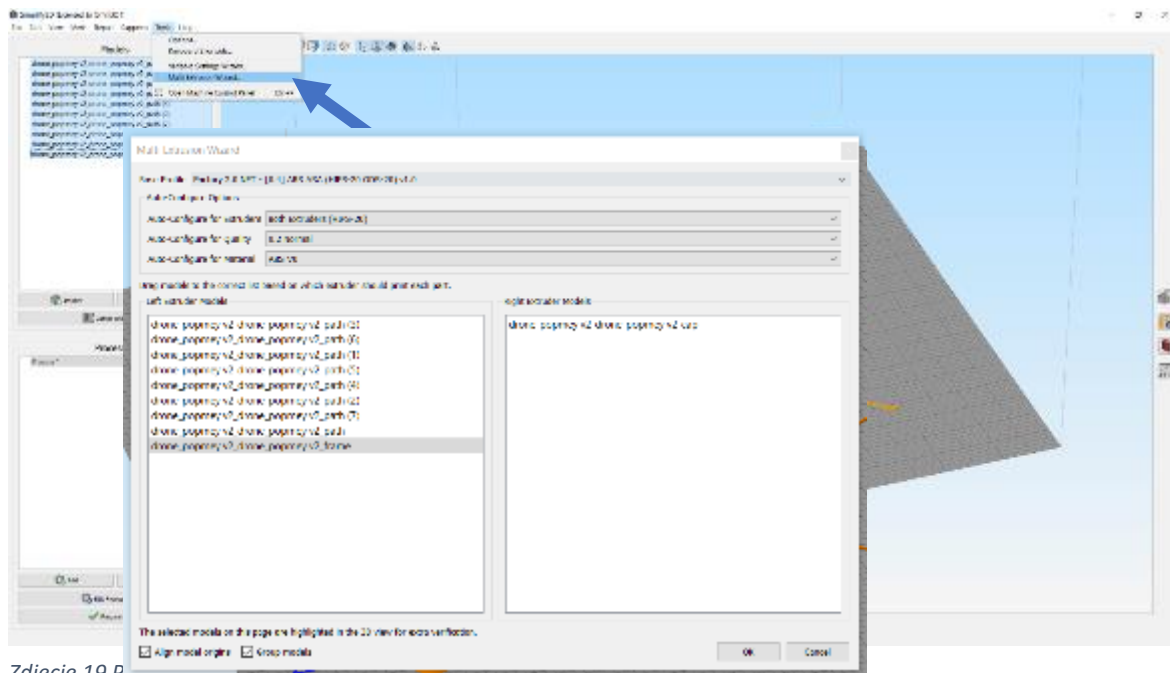
Zdjęcie 17 Pole zmiany kolorystyki ścieżek.

After selecting the **Active Toolhead color** option from the **Coloring panel** on the left side of the screen, the paths will be colored in the color corresponding to the tool that is to perform them. The navy blue color shows the substrate printed with the first head, while the light green color shows the low-melting metal path printed with the second head.

In this way, it is also possible to prepare more complex structures, e.g. a low-melting alloy track printed on all sides with plastic (Figure no.)



The Simplify3D program also has a tool that allows you to assign models to the print head faster. The operation of this tool will be presented on the example of a drone with integrated paths.



Zdjęcie 19 Przegląd funkcji Multi Extrusion Wizard w programie Simplify3D

Zdjęcie 20 Okno funkcji Multi Extrusion Wizard

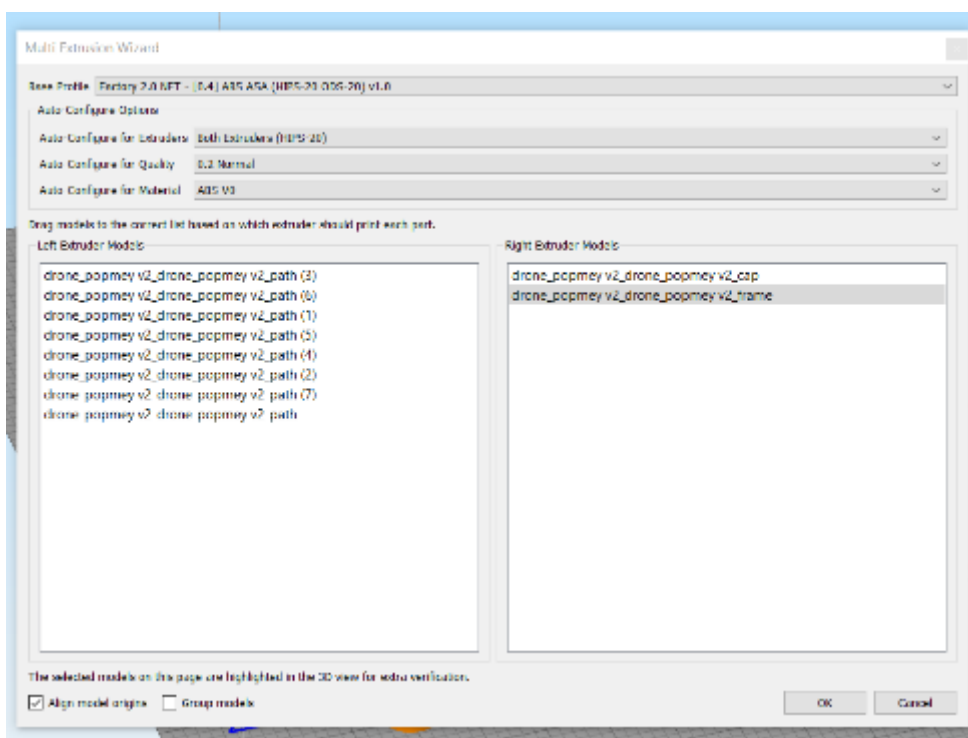
After importing the models, select the **Multi Extrusion functions Wizard ...** from the Tools tab (photo 19)

A window will appear in which you can assign a model to the printhead.

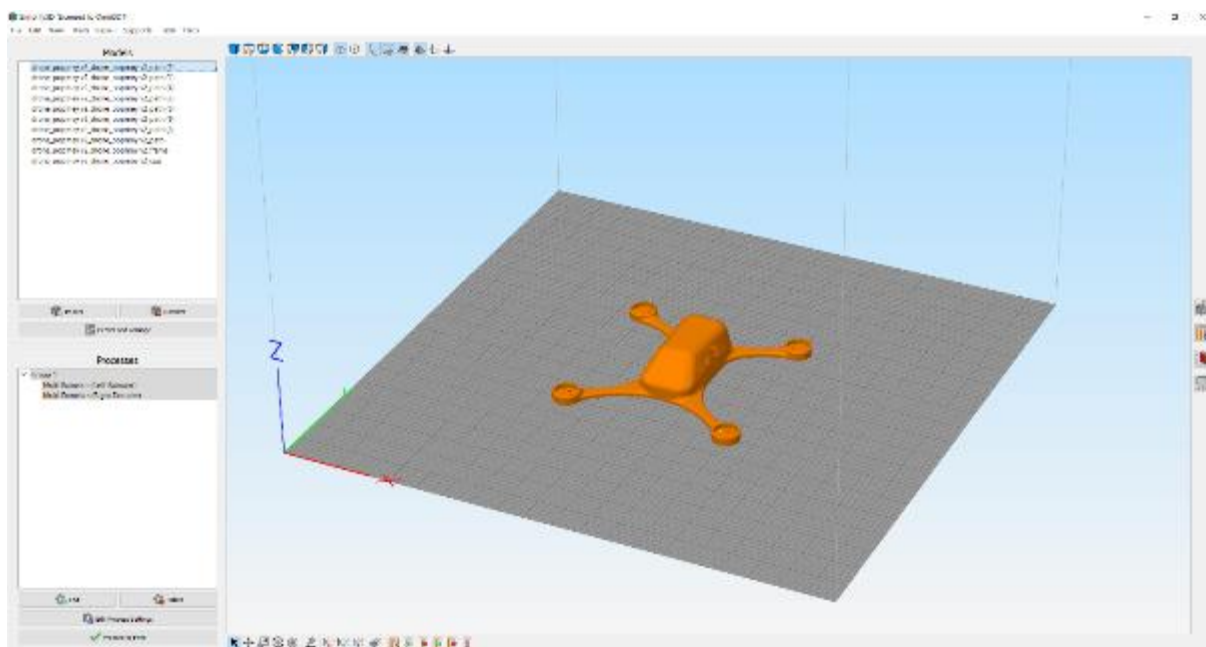
After selecting the model name by clicking on it with the left mouse button, it is possible to move it from one extruder field to another.

We also uncheck the **Group field models** .

After making changes, confirm them by clicking the left mouse button on the **OK button** .



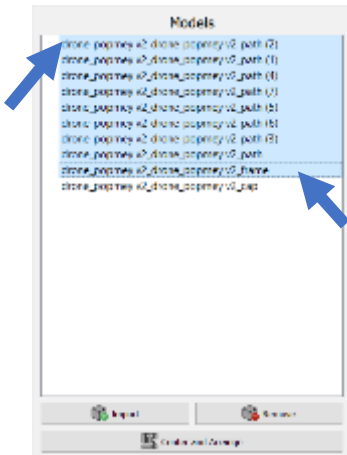
Zdjęcie 21 Przypisanie modeli pod głowice drukujące w funkcji Multi Extrusion Wizard



Zdjęcie 22 Platforma robocza drukarki w programie Simplify 3D po zastosowaniu funkcji Multi Extrusion Wizard na zaimportowanych modelach.

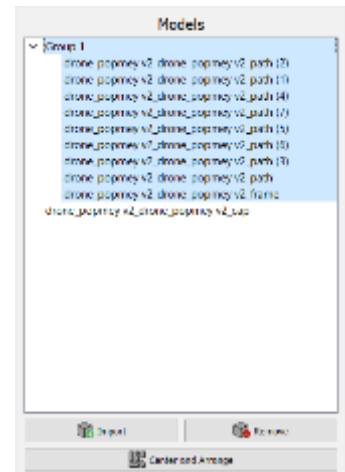
After closing the window, the models will be arranged as they were modeled in the CAD program (Photo 22).

Due to the fact that the drone has a detachable dome, you should change its orientation on the table, thus facilitating its execution.



To do this, you must group all models together except for the dome model. To group models, first select them from the **Models field** (Photo 23). First, left-click on the first name of the model, then hold down the Shift key and left-click on the last name of the model to be grouped (Photo 23).

After selecting the models, press the Ctrl+G key combination. After completing the above steps, the **Models window** should look like this (Picture 24).

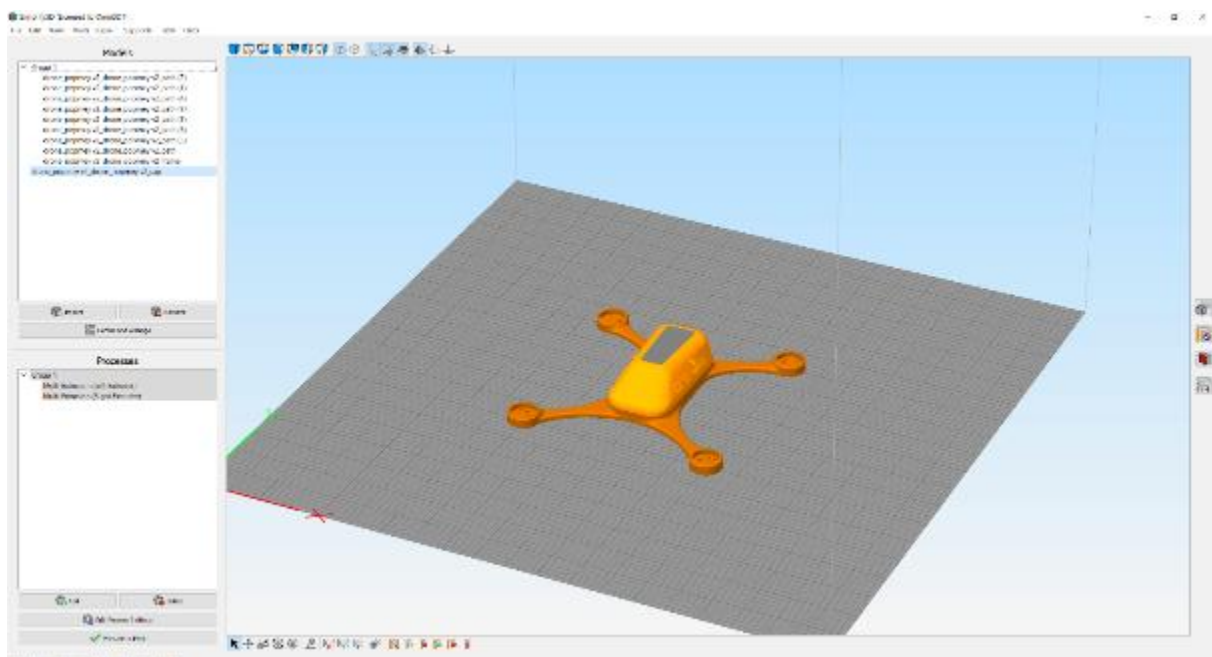


Zdjęcie 23 Graficzna reprezentacja zaznaczenia modeli w panelu Models.

Zdjęcie 24 Graficzna reprezentacja przypisania modeli do grupy w panelu Models

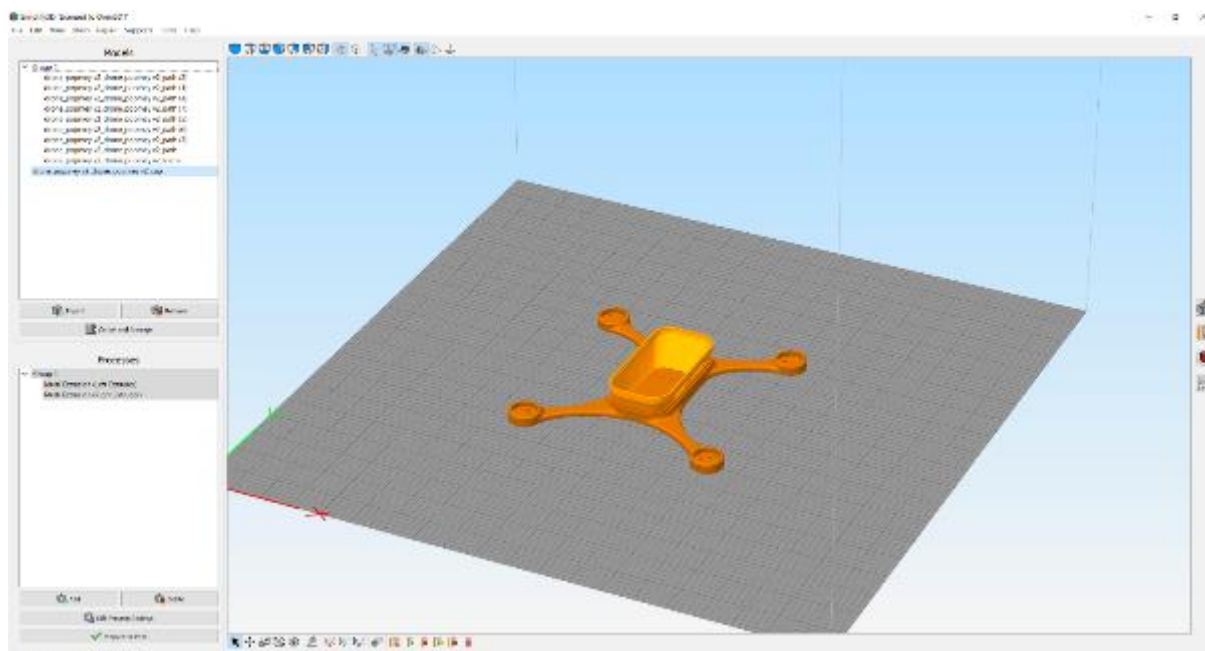
Now reorient the dome model on the table using **Place Surface on Bed**.

Press the Ctrl+L key combination and hover the mouse cursor over the top surface of the dome. It will then be highlighted in gray (Photo 25).



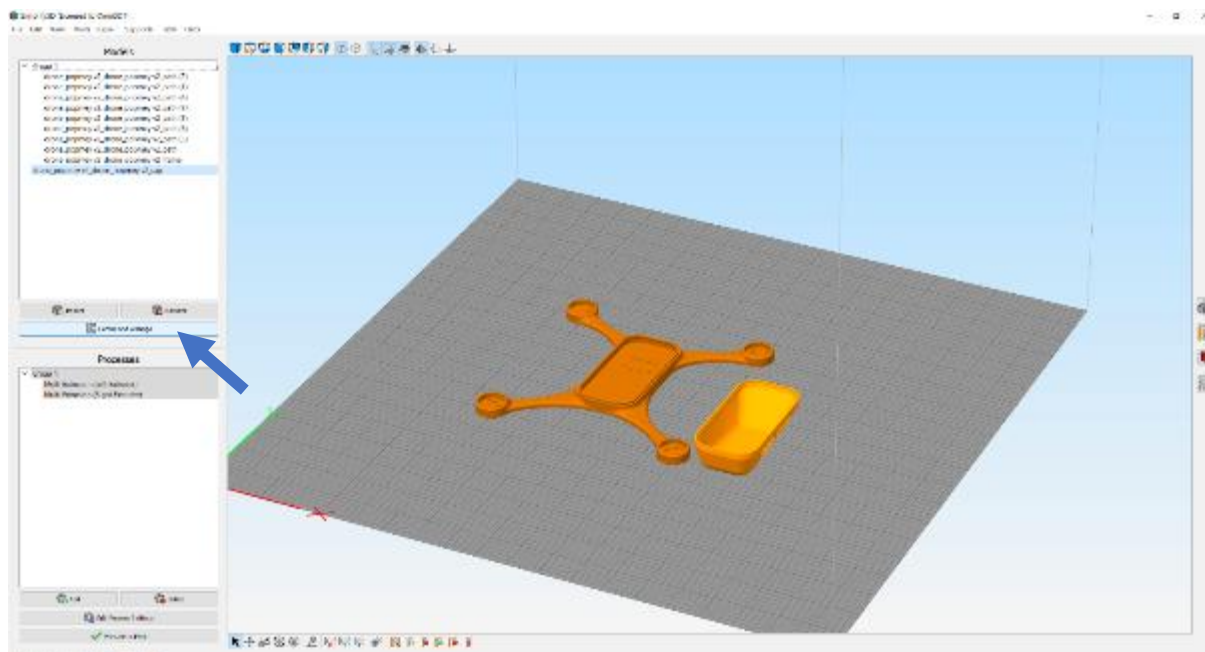
Zdjęcie 25 Zaznaczenie ściany modelu 3D po wciśnięciu kombinacji klawiszy ctrl+L oraz najechaniu krusosem myszy.

When the upper surface of the dome changes color, confirm the selection by clicking the left mouse button on this surface. After performing this operation, the working platform should look like in photo 26.



Zdjęcie 26 Efekt funkcji Place Surface on Bed

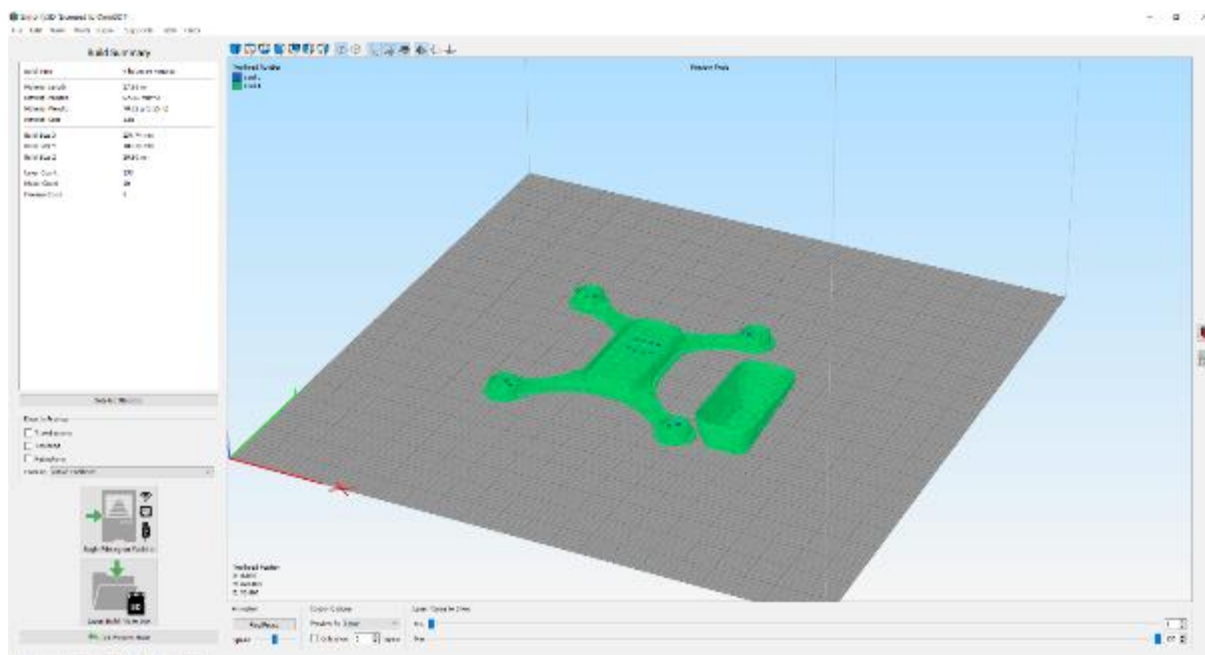
The last step is the optimal placement of the models on the build table.  
To do this, click the left mouse button on the **Center and Arrange** button (Photo 27)



Zdjęcie 27 Położenie przycisku Center and Arrange w interfejsie programu oraz efekt jej zastosowania.

At this point, you can proceed to generate the machine code by clicking the **Prepare to Print** button .

A new screen will then appear with the generated paths colored depending on which printheads they are assigned to (Photo 28).



Zdjęcie 28 Wizualizacja ścieżek.

## Conclusions

The analysis of the case study shows that the Simplify3D software allows you to generate a 3D printing path for hybrid 3D printing technology using extrusion of polymer and metal materials. At the design stage, the element should be separated as separate 3D models designed to be made of polymer and metal. The program gives you the ability to assign a specific type of head to each model separately. Thanks to this, the generated gcode will contain commands to select a specific head (T0 or T1). The system used does not require modification of the 3D printer firmware in this respect. As standard, the 3D printer supports head selection commands (T0, T1, etc.), which in normal use are intended for switching between the model printing head and the printing support.

In the extended configuration, the program can also generate paths for more heads, for example printing with different types of polymers or metals during one printing process.

Simplify3D can only generate layers in the XY plane. It is not possible to generate a path that would assume simultaneous synchronized movement in the Z axis (non-planar printing).

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