CLAIMS

What is claimed is:

1. A method for detecting a set of targets comprising biomarkers of a sample, the method comprising:

capturing a set of cells of the sample in proximity to a set of functionalized particles, in single cell format, at a first set of microwells of a sample processing substrate;

performing lysis of the set of cells, at the sample processing substrate, thereby allowing binding of released biomarkers from the set of cells to the set of functionalized particles;

performing a reverse transcription operation, at the first set of microwells of the sample processing substrate, with said biomarkers bound to the set of functionalized particles;

with products of the reverse transcription operation, performing a second strand synthesis operation with the set of functionalized particles;

with products of the second strand synthesis operation, performing an amplification operation at the set of functionalized particles;

hybridizing each of a set of probes, corresponding to a set of fluorophores, to products of the amplification operation; and

generating an image dataset of light emitted by the set of probes, thereby enabling detection of the set of targets of the sample.

2. The method of Claim 1, wherein the set of targets comprises a panel of antibodies for assessment of immune responses from a subject, the panel of antibodies comprising one or more of: IgM antibodies, IgG antibodies, IgD antibodies, IgA antibodies, and IgE antibodies.

3. The method of Claim 2, wherein the panel of antibodies comprises antibodies for severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2).

4. The method of Claim 1, wherein the set of targets comprises a panel of mRNA molecules.

5. The method of Claim 4, further comprising performing a spatial transcriptomics analysis of the panel of mRNA molecules, with the sample distributed across the sample processing substrate.

6. The method of Claim 1, wherein capturing the set of cells of the sample in proximity to the set of functionalized particles comprises delivering the set of cells to the first set of microwells of the sample processing substrate, and positioning the set of functionalized particles within a second set of microwells of a second substrate aligned with and facing the first set of microwells.

7. The method of Claim 6, further comprising compressing the second substrate, with the second set of microwells, against the first set of microwells, thereby partitioning individual wells of the sample processing substrate and allowing said biomarkers derived from the set of cells to diffuse toward the set of functionalized particles at the second substrate.

8. The method of Claim 7, wherein compressing the second substrate, with the second set of microwells, against the first set of microwells, comprises actuating a heating object against the second substrate, thereby providing compression and heating contents of at least one of the sample processing substrate and the second substrate.

9. The method of Claim 1, wherein hybridizing each of the set of probes comprises hybridizing a first subset of the set of probes, corresponding to a first fluorophore, and performing a first detection operation; de-hybridizing and washing the first subset of probes; and hybridizing a second subset of the set of probes, corresponding to a second fluorophore, and performing a second detection operation.

10. The method of Claim 1, wherein the set of probes (P) is configured for multiplexed detection of the set of targets, where the set of fluorophores (F) has a set of melting points (M), thereby enabling multiplexing of $M^*F^P$ targets at the sample processing substrate.

11. The method of Claim 1, further comprising performing an mRNA quantitation operation with estimation of initial concentrations of mRNAs captured at the set of functionalized particles, based upon a set of fluorescence values from the image data set and a number of amplification cycles performed.

12. A method for detecting a set of targets comprising biomarkers of a sample, the method comprising:

capturing a tissue sample in proximity to a set of functionalized particles, in single array format, at a set of microwells of a sample processing substrate;

performing lysis of the tissue sample, at the sample processing substrate, thereby allowing binding of released biomarkers from the tissue section to the set of functionalized particles;

performing a reverse transcription operation, at the set of microwells of the sample processing substrate, with said biomarkers bound to the set of functionalized particles;

with products of the reverse transcription operation, performing a second strand synthesis operation with the set of functionalized particles;

with products of the second strand synthesis operation, performing an amplification operation at the set of functionalized particles;

hybridizing each of a set of probes, corresponding to a set of fluorophores, to products of the amplification operation; and

generating an image dataset of light emitted by the set of probes, thereby enabling detection of the set of targets of the sample.

13. The method of Claim 12, wherein the set of targets comprises a panel of antibodies for assessment of immune responses from a subject, the panel of antibodies

comprising one or more of: IgM antibodies, IgG antibodies, IgD antibodies, IgA antibodies, and IgE antibodies.

14. The method of Claim 13, wherein the panel of antibodies comprises antibodies for severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2).

15. The method of Claim 12, wherein the set of targets comprises a panel of mRNA molecules.

16. The method of Claim 15, further comprising performing a spatial transcriptomics analysis of the panel of mRNA molecules, with the sample distributed across the sample processing substrate.