CLAIMS

What is claimed is:

1. A method of operating a computing device to generate information for a concurrent test plan for a device having a plurality of pins and to be performed by a test system having a plurality of resources, the method comprising:

with at least one processor:

a) identifying a plurality of groups of pins and a set of resource requirements during a test for each of the groups;

b) identifying a plurality of sets of test system resources, each of the sets comprising one or more test system resources that collectively meet a requirement; and

c) matching sets of the plurality of sets to respective groups of the plurality of groups.

2. The method of claim 1, wherein:

the sets of the plurality of sets have an order; and

the matching comprises assigning a group of the plurality of groups to each of the sets in the order until a group is assigned to each of the plurality of sets.

3. The method of claim 2, further comprising:

d) assigning a score to each of the plurality of sets, the score indicating a degree of difficulty of matching resources to requirements of the set; and

e) establishing the order of the plurality of sets based on the scores assigned to the plurality of sets.

4. The method of claim 1, wherein:

the method further comprises:

d) upon matching a group of the plurality of groups to a set of the plurality of sets, assigning resources in the set to pins in the group;

the sets of the plurality of sets have an order; and

the matching comprises assigning a group of the plurality of groups to each of the sets in the order until a next set in the order is reached for which there is no unassigned resource meeting a requirement for the next set.

5. The method of claim 4, further comprising:

e) when there is no unassigned resource meeting a requirement for the next set, repeating act c), matching at least one different group of the plurality of groups to a set that the precedes the next set in the order.

6. The method of claim 5, further comprising:

f) repeating act e) until a group is assigned to each of the plurality of sets; and

g) generating a mapping between pins and tester resources based on the assignments of tester resources to pins in the act d).

7. The method of claim 6, wherein:

the test comprises a plurality of blocks; and

the set of resources requirements associated with each group of pins comprises collective resource requirements for pins in the group during all blocks of the test.

8. The method of claim 6, wherein:

the test comprises a plurality of blocks; and

the set of resources requirements associated with each group of pins comprises collective resource requirements for pins in the group during a portion of the blocks of the test.

9. The method of claim 1, wherein:

the method further comprises:

d) identifying a plurality of possible test flows; and

e) ordering the possible test flows based on projected test execution time;

the act a) is performed for a first test flow;

when test system resources cannot be assigned to all of the plurality of pins to meet the sets of requirements for all of the plurality of groups, repeating at least the act a) and c) for second test flow, the second test flow following the first test flow in the order.

10. A method of manufacturing a semiconductor device, the method comprising:

generating a test plan according to the method of claims 1;

testing devices as part of a manufacturing operation according to the generated test plan; and

selecting at least one process step during the process of manufacturing the tested devices based at least in part on results of the tests.

11. At least one computer storage medium comprising computer-executable instructions that, when executed, implement a method of interacting with a user, the method comprising:

a) identifying a plurality of groups of pins and a set of resource requirements during a test for each of the groups;

b) identifying a plurality of sets of test system resources, the each of the sets comprising one or more test system resources that collectively meet a requirement; and

c) matching sets of the plurality of sets to respective groups of the plurality of groups.

12. The at least one computer storage medium of claim 11, wherein:

identifying the plurality of groups of pins comprises identifying groups associated with blocks concurrently executing within a flow step of a candidate flow;

the method further comprises, when the plurality of sets are inadequate to match every group of the plurality of groups to a set, indicating that the candidate flow has failed.

13. The at least one computer storage medium of claim 12, wherein: the method further comprises receiving user input specifying the candidate flow.

14. The at least one computer storage medium of claim 13, wherein:

the method comprises iteratively repeating the acts a), b) and c) for each of a plurality of flow steps in the candidate flow until the candidate flow fails or each of the plurality of groups is matched to a respective set of the plurality of sets.

15. A method of operating a computing device to generate information for a plan for concurrent test of at least one device, each of the at least one devices having a plurality of pins, and the test being performed by a test system having a plurality of resources connectable to the plurality of pins, the concurrent test comprising a plurality of blocks, the method comprising:

with at least one processor, iteratively performing processing comprising:

identifying a candidate flow in accordance with a heuristic, the candidate flow scheduling blocks to avoid previously identified conflicts between blocks;

for the candidate flow:

attempting to allocate resources of the plurality of resources to pins of the plurality of pins to execute the concurrent test according to the candidate flow;

when the attempting to allocate results in a successful allocation of resources, computing the test time for executing the concurrent test using the candidate flow;

when an allocation of resources is not successful because of a conflict between test blocks, recording the conflict between conflicting test blocks so that candidate flows in subsequent iterations do not include the conflict.

16. The method of claim 15, wherein:

in a second iteration, identifying a candidate flow in accordance with the heuristic comprises randomly generating a candidate flow that has characteristics indicated by the heuristic to execute the concurrent test in a time shorter than a test time computed during a prior iteration for a prior candidate flow.

17. The method of claim 15, wherein:

identifying a candidate flow in accordance with the heuristic in each of a plurality of iterations comprises generating candidate flows in an order, predicted by the heuristic, to execute in successively longer times.

18. The method of claim 15, further comprising:

providing as an output an indication of a candidate flow for which an allocation of resources is successful.

19. The method of claim 18, further comprising:

selecting the output candidate flow from among a plurality of candidate flows for which an allocation of resources is successful, the output candidate flow being selected based on computed test times for the plurality of candidate flows.

20. The method of claim 15, wherein:

the method further comprises receiving input providing an execution time estimate for each of the plurality of test blocks; and

computing the test time for a candidate flow comprises computing the test time based on the execution time estimates.

21. The method of claim 15, wherein the conflict comprises a requirement for resources to concurrently test the conflicting test blocks that exceeds the resources of the test system.

22. The method of claim 15, wherein the conflict comprises a requirement for a pin of the device under test to operate in at least two of the conflicting test blocks.

23. The method of claim 15, further comprising:

receiving user input defining a new configuration of the test system; and

repeating the act of iteratively performing processing based on the new configuration.

24. The method of claim 23, wherein:

receiving the user input and repeating the act of iteratively performing processing occurs in real time.

25. The method of claim 24, wherein:

receiving user input defining a new configuration of the test system comprises receiving user input defining a number of sites for which the test system is configured.

26. The method of claim 15, further comprising:

prior to the act of iteratively performing processing, receiving input specifying conflicting test blocks, the input identifying blocks to which a same pin has been assigned.

27. The method of claim 15, further comprising:

receiving input specifying a termination condition for the act of iteratively performing processing.

28. The method of claim 27, wherein the termination condition is expressed as a time to iteratively perform processing, a maximum number of iterations in the iteratively performing processing or a target computed test time for executing a candidate flow.

29. At least one computer-readable storage medium comprising a plurality of computer-executable instructions that, when executed by at least one processor, implement a tool for generating information for a plan for concurrent test of at least one device, each of the at least one devices having a plurality of pins, and the test being performed by a test system having a plurality of resources connectable to the plurality of

pins, the concurrent test comprising a plurality of blocks, the computer-executable instructions comprising:

a plurality of modules, the plurality of modules comprising at least two modules selected from a group consisting of:

a first module for, in response to input designating a first technique, identifying at least one flow for concurrent test by:

enumerating candidate flows;

attempting to allocate resources of the plurality of resources to pins of the plurality of pins to execute the concurrent test according to each of the enumerated candidate flows; and

providing an output indicating a plurality of the enumerated candidate flows for which the allocation of resources is successful and a respective estimated test time for the enumerated candidate flow;

a second module for, in response to input designating a second technique, identifying at least one flow for concurrent test by:

iteratively generating, until a first termination condition is reached, a plurality of candidate flows by randomly generating, in each iteration, a candidate flow that has characteristics indicated by a heuristic to execute the concurrent test in a time shorter than a test time for a prior candidate flow computed during a prior iteration;

for each generated candidate flow, attempting to allocate resources of the plurality of resources to pins of the plurality of pins to execute the concurrent test according to each of the enumerated candidate flows;

providing an output indicating at least one of the generated candidate flows for which the allocation of resources is successful; and

a third module for, in response to input designating a third technique, identifying at least one flow for concurrent test by:

iteratively generating, until a second termination condition is reached, a plurality of candidate flows by generating, in each iteration, a candidate flow that has characteristics indicated by a heuristic to execute the concurrent test in a time longer than a test time for a prior candidate flow computed during a prior iteration;

for each generated candidate flow, attempting to allocate resources of the plurality of resources to pins of the plurality of pins to execute the concurrent test according to each of the enumerated candidate flows;

providing an output indicating at least one of the generated candidate flows for which the allocation of resources is successful.

30. The at least one computer-readable storage medium of claim 29, wherein the computer-executable instructions comprise:

computer-executable instructions for receiving input specifying a candidate flow and determining whether resources of the plurality of resources can be successfully allocated to pins of the plurality of pins to execute the concurrent test according to the input candidate flow.

31. The at least one computer-readable storage medium of claim 29, wherein the computer-executable instructions comprise:

computer-executable instructions for receiving an input specifying the first termination condition or the second termination condition.

32. The at least one computer-readable storage medium of claim 29, wherein:

the computer-executable instructions comprise computer-executable instructions for receiving input specifying a maximum number of concurrent test blocks in each of the plurality of candidate flows generated by the second module or the third module.

33. The at least one computer-readable storage medium of claim 29, wherein:

the computer-executable instructions comprise computer-executable instructions for receiving input specifying a minimum number of flow steps in each of the plurality of candidate flows generated by the second module or the third module.

34. The at least one computer-readable storage medium of claim 29, wherein:

the computer-executable instructions comprise computer-executable instructions for receiving input specifying a pattern of test blocks to apply in the plurality of candidate flows generated by the second module or the third module.

35. The at least one computer-readable storage medium of claim 34, wherein: the pattern of test blocks comprises test blocks for concurrent execution.

36. The at least one computer-readable storage medium of claim 34, wherein: the pattern of test blocks comprises test blocks for sequential execution.

37. The at least one computer-readable storage medium of claim 34, wherein: enumerating candidate flows comprises generating all possible unique test flows.

38. At least one computer-readable storage medium comprising a plurality of computer-executable instructions that, when executed by at least one processor, implement a tool for generating information for a plan for concurrent test of at least one device, each of the at least one devices having a plurality of pins, and the test being performed by a test system having a plurality of resources connectable to the plurality of pins, the concurrent test comprising a plurality of blocks, the computer-executable instructions for:

receiving input specifying a test system configuration;

receiving input specifying a candidate flow;

determining whether resources of the plurality of resources can be successfully allocated to pins of the plurality of pins to execute the concurrent test according to the input candidate flow with the specified test system configuration.

39. The at least one computer-readable storage medium of claim 38, wherein: receiving input specifying a test system configuration comprises receiving input specifying a number to test sites that the test system is configured to test.

40. The at least one computer-readable storage medium of claim 38, wherein: receiving input specifying a test system configuration comprises receiving input specifying a quantity of a resource in the test system.

CLAIMS

What is claimed is:

1. A method of operating a computing device to generate information for a concurrent test plan for a device having a plurality of pins and to be performed by a test system having a plurality of resources, the method comprising:

with at least one processor:

a) for each group of a plurality of groups of pins, identifying a set of resource requirements, wherein the set of resource requirements comprises resources required for performing a test of the group of the plurality of groups;

b) identifying a plurality of sets of test system resources, each of the plurality of sets comprising one or more test system resources that collectively meet a requirement; and

c) matching sets of the plurality of sets of test system resources to respective groups of the plurality of groups.

2. The method of claim 1, wherein:

the sets of the plurality of sets have an order; and

the matching comprises assigning a group of the plurality of groups to each of the sets in the order until a group is assigned to each of the plurality of sets.

3. The method of claim 2, further comprising:

d) assigning a score to each of the plurality of sets, the score indicating a degree of difficulty of matching resources to requirements of the set; and

e) establishing the order of the plurality of sets based on the scores assigned to the plurality of sets.

4. The method of claim 1, wherein:

the method further comprises:

d) upon matching a group of the plurality of groups to a set of the plurality of sets, assigning resources in the set to pins in the group;

the sets of the plurality of sets have an order; and

the matching comprises assigning a group of the plurality of groups to each of the sets in the order until a next set in the order is reached for which there is no unassigned resource meeting a requirement for the next set.

5. The method of claim 4, further comprising:

e) when there is no unassigned resource meeting a requirement for the next set, repeating act c), matching at least one different group of the plurality of groups to a set that the precedes the next set in the order.

6. The method of claim 5, further comprising:

f) repeating act e) until a group is assigned to each of the plurality of sets; and

g) generating a mapping between pins and tester resources based on the assignments of tester resources to pins in the act d).

7. The method of claim 6, wherein:

the test comprises a plurality of blocks; and

the set of resource requirements associated with each group of pins comprises collective resource requirements for pins in the group during all blocks of the test.

8. The method of claim 6, wherein:

the test comprises a plurality of blocks; and

the set of resource requirements associated with each group of pins comprises collective resource requirements for pins in the group during a portion of the blocks of the test.

9. The method of claim 1, wherein:

the method further comprises:

d) identifying a plurality of possible test flows; and

e) ordering the possible test flows based on projected test execution time;

the act a) is performed for a first test flow;

when test system resources cannot be assigned to all of the plurality of pins to meet the sets of requirements for all of the plurality of groups, repeating at least the act a) and c) for second test flow, the second test flow following the first test flow in the order.

10. A method of manufacturing a semiconductor device, the method comprising:

generating a test plan according to the method of claim 1;

testing devices as part of a manufacturing operation according to the generated test plan; and

selecting at least one process step during the process of manufacturing the tested devices based at least in part on results of the tests.

11. At least one non-transitory computer storage medium comprising computer-executable instructions that, when executed by at least one computing device, implement a method of interacting with a user, the method comprising:

a) for each group of a plurality of groups of pins, identifying a set of resource requirements, wherein the set of resource requirements comprises resources required for performing a test of the group of the plurality of groups;

b) identifying a plurality of sets of test system resources, each of the plurality of sets comprising one or more test system resources that collectively meet a requirement; and

c) matching sets of the plurality of sets of test system resources to respective groups of the plurality of groups.

12. The at least one computer storage medium of claim 11, wherein:

identifying the plurality of groups of pins comprises identifying groups associated with blocks concurrently executing within a flow step of a candidate flow;

the method further comprises, when the plurality of sets are inadequate to match every group of the plurality of groups to a set, indicating that the candidate flow has failed.

13. The at least one computer storage medium of claim 12, wherein: the method further comprises receiving user input specifying the candidate flow.

14. The at least one computer storage medium of claim 13, wherein:

the method comprises iteratively repeating the acts a), b) and c) for each of a plurality of flow steps in the candidate flow until the candidate flow fails or each of the plurality of groups is matched to a respective set of the plurality of sets.

15. A method of operating a computing device to generate information for a plan for concurrent test of at least one device, each of the at least one devices having a plurality of pins, and the test being performed by a test system having a plurality of resources connectable to the plurality of pins, the concurrent test comprising a plurality of blocks, the method comprising:

with at least one processor, iteratively performing processing comprising:

identifying a candidate flow in accordance with a heuristic, the candidate flow scheduling blocks to avoid previously identified conflicts between blocks;

for the candidate flow:

attempting to allocate resources of the plurality of resources to pins of the plurality of pins to execute the concurrent test according to the candidate flow;

when the attempting to allocate results in a successful allocation of resources, computing the test time for executing the concurrent test using the candidate flow;

when an allocation of resources is not successful because of a conflict between test blocks, recording the conflict between conflicting test blocks so that candidate flows in subsequent iterations do not include the conflict.

16. The method of claim 15, wherein:

in a second iteration, identifying a candidate flow in accordance with the heuristic comprises randomly generating a candidate flow that has characteristics indicated by the heuristic to execute the concurrent test in a time shorter than a test time computed during a prior iteration for a prior candidate flow.

17. The method of claim 15, wherein:

identifying a candidate flow in accordance with the heuristic in each of a plurality of iterations comprises generating candidate flows in an order, predicted by the heuristic, to execute in successively longer times.

18. The method of claim 15, further comprising:

providing as an output an indication of a candidate flow for which an allocation of resources is successful.

19. The method of claim 18, further comprising:

selecting the output candidate flow from among a plurality of candidate flows for which an allocation of resources is successful, the output candidate flow being selected based on computed test times for the plurality of candidate flows.

20. The method of claim 15, wherein:

the method further comprises receiving input providing an execution time estimate for each of the plurality of test blocks; and

computing the test time for a candidate flow comprises computing the test time based on the execution time estimates.

21. The method of claim 15, wherein the conflict comprises a requirement for resources to concurrently test the conflicting test blocks that exceeds the resources of the test system.

22. The method of claim 15, wherein the conflict comprises a requirement for a pin of the device under test to operate in at least two of the conflicting test blocks.

23. The method of claim 15, further comprising:

receiving user input defining a new configuration of the test system; and

repeating the act of iteratively performing processing based on the new configuration.

24. The method of claim 23, wherein:

receiving the user input and repeating the act of iteratively performing processing occurs in real time.

25. The method of claim 24, wherein:

receiving user input defining a new configuration of the test system comprises receiving user input defining a number of sites for which the test system is configured.

26. The method of claim 15, further comprising:

prior to the act of iteratively performing processing, receiving input specifying conflicting test blocks, the input identifying blocks to which a same pin has been assigned.

27. The method of claim 15, further comprising:

receiving input specifying a termination condition for the act of iteratively performing processing.

28. The method of claim 27, wherein the termination condition is expressed as a time to iteratively perform processing, a maximum number of iterations in the iteratively performing processing or a target computed test time for executing a candidate flow.

29. At least one non-transitory computer-readable storage medium comprising a plurality of computer-executable instructions that, when executed by at least one processor, implement a tool for generating information for a plan for concurrent test of at least one device, each of the at least one devices having a plurality of pins, and

the test being performed by a test system having a plurality of resources connectable to the plurality of pins, the concurrent test comprising a plurality of blocks, the computer-executable instructions comprising:

a plurality of modules, the plurality of modules comprising at least two modules selected from a group consisting of:

a first module for, in response to input designating a first technique, identifying at least one flow for concurrent test by:

enumerating candidate flows;

attempting to allocate resources of the plurality of resources to pins of the plurality of pins to execute the concurrent test according to each of the enumerated candidate flows; and

providing an output indicating a plurality of the enumerated candidate flows for which the allocation of resources is successful and a respective estimated test time for the enumerated candidate flow;

a second module for, in response to input designating a second technique, identifying at least one flow for concurrent test by:

iteratively generating, until a first termination condition is reached, a plurality of candidate flows by randomly generating, in each iteration, a candidate flow that has characteristics indicated by a heuristic to execute the concurrent test in a time shorter than a test time for a prior candidate flow computed during a prior iteration;

for each generated candidate flow, attempting to allocate resources of the plurality of resources to pins of the plurality of pins to execute the concurrent test according to each of the enumerated candidate flows;

providing an output indicating at least one of the generated candidate flows for which the allocation of resources is successful; and

a third module for, in response to input designating a third technique, identifying at least one flow for concurrent test by:

iteratively generating, until a second termination condition is reached, a plurality of candidate flows by generating, in each iteration, a candidate flow that has characteristics indicated by a heuristic to execute

the concurrent test in a time longer than a test time for a prior candidate flow computed during a prior iteration;

for each generated candidate flow, attempting to allocate resources of the plurality of resources to pins of the plurality of pins to execute the concurrent test according to each of the enumerated candidate flows;

providing an output indicating at least one of the generated candidate flows for which the allocation of resources is successful.

30. The at least one computer-readable storage medium of claim 29, wherein the computer-executable instructions comprise:

computer-executable instructions for receiving input specifying a candidate flow and determining whether resources of the plurality of resources can be successfully allocated to pins of the plurality of pins to execute the concurrent test according to the input candidate flow.

31. The at least one computer-readable storage medium of claim 29, wherein the computer-executable instructions comprise:

computer-executable instructions for receiving an input specifying the first termination condition or the second termination condition.

32. The at least one computer-readable storage medium of claim 29, wherein:

the computer-executable instructions comprise computer-executable instructions for receiving input specifying a maximum number of concurrent test blocks in each of the plurality of candidate flows generated by the second module or the third module.

33. The at least one computer-readable storage medium of claim 29, wherein:

the computer-executable instructions comprise computer-executable instructions for receiving input specifying a minimum number of flow steps in each of the plurality of candidate flows generated by the second module or the third module.

34. The at least one computer-readable storage medium of claim 29, wherein:

the computer-executable instructions comprise computer-executable instructions for receiving input specifying a pattern of test blocks to apply in the plurality of candidate flows generated by the second module or the third module.

35. The at least one computer-readable storage medium of claim 34, wherein: the pattern of test blocks comprises test blocks for concurrent execution.

36. The at least one computer-readable storage medium of claim 34, wherein: the pattern of test blocks comprises test blocks for sequential execution.

37. The at least one computer-readable storage medium of claim 34, wherein: enumerating candidate flows comprises generating all possible unique test flows.

38. At least one non-transitory computer-readable storage medium comprising a plurality of computer-executable instructions that, when executed by at least one processor, implement a tool for generating information for a plan for a concurrent test of at least one device, each of the at least one devices having a plurality of pins, and the test being performed by a test system having a plurality of resources connectable to the plurality of pins, the concurrent test comprising a plurality of blocks, the computer-executable instructions for:

receiving input specifying a test system configuration;

receiving input specifying a candidate flow; and

determining whether resources of the plurality of resources can be successfully allocated to pins of the plurality of pins to execute the concurrent test according to the input candidate flow with the specified test system configuration.

39. The at least one computer-readable storage medium of claim 38, wherein:

receiving input specifying a test system configuration comprises receiving input specifying a number to test sites that the test system is configured to test.

40. The at least one computer-readable storage medium of claim 38, wherein:

receiving input specifying a test system configuration comprises receiving input specifying a quantity of a resource in the test system.